Volume 36 • APRIL, 1955 • No. 4

Archives of PHYSICAL MEDICINE *and* REHABILITATION

ORIGINAL ARTICLES

Analysis of Results of Training 400 A/K Amputees. William J. Erdman II, M.D., and Emilie L. Maxwell, M.D. 209

Physical Therapeutic Aspects in the Treatment of Third Degree Burns. Charles S. Wise, M.D.; Gordon S. Letterman, M.D.; Maxine Schurter, M.D., and Jessie E. Fair, R.P.T. 212

An Electromyographic Study of Some of the Muscles Used in Respiration. George H. Koepke, M.D.; Alma J. Murphy, Ph.D.; James W. Rae, Jr., M.D., and David G. Dickinson, M.D. 217

Psychogenic Rheumatism. Edward W. Lowman, M.D. 222

Effect of Posture and Local Pressure on Venous Circulation Time of the Leg. Harry T. Zankel, M.D.; R. A. Shipley, M.D., and R. E. Clark, B.S. 226

A Double Purpose Whirlpool. J. L. Rudd, M.D. 232

Performance and Metabolic Alterations During Betaine Glycocyamine Feeding in Myasthenia Gravis. Harvey E. Billig, Jr., M.D., and Laurence E. Morehouse, Ph.D. 233

(continued on inside front cover)

Editor of the Month

ARTHUR L. WATKINS, M.D.

Boston

ANNUAL SESSION • DETROIT • AUG. 28 - SEPT. 2, 1955

ORIGINAL ARTICLES

(continued from front cover)

Myositis Ossificans Complicating Poliomyelitis. J. P. Stoikovic, M.D.; M. Bonfiglio, M.D., and William D. Paul, M.D. 236

•

The Arthritic Foot: A Method of Taking Weight-Bearing Impressions for the Making of Supports. Robert Muller, M.D. 244

•

Functional Significance of Spinal Cord Lesion Level. Charles Long II, M.D., and Edith Buchwald Lawton, M.A., A.R.P.T. 249

•

Editorial Board Adds New Members 256

•

Medical News 257

•

Physical Medicine Abstracts 259

IN THE HOSPITAL
Hydrocollator Master Unit maintains ready supply
IN THE HOME
Heat in any vessel on stove
UL
NO WRINGING
NO DRIPPING
WRAP IN TOWEL
30 MINUTES MOIST HEAT WITH EACH APPLICATION
APPLY
EFFECTIVE
MOIST HEAT
EASILY APPLIED
HYDROCOLLATOR
Steam PACK
Everyone agrees moist heat is most effective in reducing spasm and pain. Now it can be easily and efficiently applied! Hydrocollator Steam Packs require no wringing, won't drip, are easy to prepare and handle. In use in leading hospitals and treatment centers.
ACCEPTED BY THE COUNCIL ON PHYSICAL MEDICINE AND REHABILITATION (AMA)
WRITE FOR DESCRIPTIVE FOLDER
CHATTANOOGA PHARMACAL COMPANY, INC.
CHATTANOOGA 5, TENNESSEE

ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION

30 North Michigan Avenue, Chicago 2, Illinois

OFFICIAL JOURNAL
AMERICAN CONGRESS OF PHYSICAL MEDICINE AND REHABILITATION
AMERICAN SOCIETY OF PHYSICAL MEDICINE AND REHABILITATION

Original contributions, exchanges and books for review should be forwarded to the Editorial Office. All business matters including advertising should be handled through the Executive Office, 30 N. Michigan Ave., Chicago 2, Illinois. The statements in the manuscripts published in the ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION are made solely on the responsibility of the author. The American Congress of Physical Medicine and Rehabilitation and/or the American Society of Physical Medicine and Rehabilitation does not assume any responsibility for statements contained therein. Manuscripts accepted for publication in the ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION are for exclusive publication and may not be published elsewhere.

OFFICERS

American Congress of Physical Medicine and Rehabilitation

WILLIAM D. PAUL, M.D.
Iowa City, President
HOWARD A. RUSK, M.D.
New York, President-Elect
GORDON M. MARTIN, M.D.
Rochester, Minn., First Vice-President
A.B.C. KNUDSON, M.D.
Washington, D.C., Second Vice-President
DONALD L. ROSE, M.D.
Kansas City, Kan., Third Vice-President
ARTHUR C. JONES, M.D.
Portland, Ore., Fourth Vice-President
FREDERIC J. KOTTKE, M.D.
Minneapolis, Fifth Vice-President
FRANCES BAKER, M.D.
San Mateo, Calif., Secretary
FRANK H. KRUSEN, M.D.
Rochester, Minn., Treasurer
WALTER J. ZEITER, M.D.
Cleveland, Executive Director
DOROTHEA C. AUGUSTIN,
Chicago, Executive Secretary

EXECUTIVE COUNCIL

Wm. Benham Snow, M.D., New York, Chairman.
Norman E. Titus, M.D., Savannah, Ga., Secretary.
Robert L. Bennett, M.D., Warm Springs, Ga.
William Bierman, M.D., New York.
Earl C. Elkins, M.D., Rochester, Minn.
Kristian G. Hansson, M.D., New York.
John Severy Hibben, M.D., Pasadena.
Abraham R. Hollender, M.D., Miami Beach, Fla.
O. Leonard Huddleston, M.D., Santa Monica, Calif.
H. Worley Kendell, M.D., Peoria, Ft.
Miland E. Knapp, M.D., Minneapolis.
Disraeli Kobak, M.D., Chicago.
Frank H. Krusen, M.D., Rochester, Minn.
Walter S. McClellan, M.D., Chapel Hill, N. C.
Fred B. Moor, M.D., Los Angeles.
Nathan B. Palmer, M.D., New Orleans.
William H. Schmidt, M.D., Philadelphia.
Arthur L. Watkins, M.D., Boston.
William D. Paul, M.D., Iowa City, Ex-Officio

EDITOR EMERITUS

Disraeli Kobak, M.D., Chicago.

Subscription—In the United States, its possessions, and Mexico, $7.00 yearly; Canada, $8.00; elsewhere, $14.00 the year; $0.75 per single copy.
Advertising rates on application. All advertising copy subject to acceptance by Publication Committee.

COPYRIGHT: Matter appearing in the ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION is covered by copyright. Permission will be granted on request for reproduction in reputable publications if proper credit is given. Reproduction for commercial purposes will not be permitted.

Published monthly at Chicago, Illinois, by the American Congress of Physical Medicine and Rehabilitation. Entered as Second Class Matter at the Post Office at Chicago, Illinois.

Copyright, 1955, by The American Congress of Physical Medicine and Rehabilitation.

EDITORIAL BOARD

EARL C. ELKINS, M.D., Rochester, Minn.
ARTHUR C. JONES, M.D., Portland, Ore.
FREDERIC J. KOTTKE, M.D., Minneapolis
FRED B. MOOR, M.D., Los Angeles
PAUL A. NELSON, M.D., Cleveland
GEORGE M. PIERSOL, M.D., Philadelphia
ARTHUR L. WATKINS, M.D., Boston

CONSULTANTS TO EDITORIAL BOARD

C. KNIGHT ALDRICH, M.D., Minneapolis
LENOX D. BAKER, M.D., Durham, N.C.
LEO BARTEMEIER, M.D., Baltimore
CYRIL COURVILLE, M.D., Los Angeles
ROBERT C. DARLING, M.D., New York City
OTTO GLASSER, Ph.D., Cleveland
JAMES G. GOLSETH, M.D., Pasadena, Calif.
W. HENRY HOLLINSHEAD, Ph.D., Rochester, Minn.
WILLIAM KUBICEK, Ph.D., Minneapolis
IRVINE McQUARRIE, M.D., Minneapolis

The ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION is devoted to the publication of significant articles in this particular field. Contributions of interest to those in physical medicine and rehabilitation are invited. Articles are accepted only with the understanding that they are contributed exclusively to the ARCHIVES. Articles and accompanying illustrations become the property of the journal.

MANUSCRIPTS

Submit only the original copy of the article, but retain a copy for use in correcting galley proofs. Carbon copies are not acceptable for editing and typesetting purposes.

REFERENCES

References should be placed at the end of the manuscript and should conform to the style of the Quarterly Cumulative Index Medicus.

ILLUSTRATIONS

Only reproducible illustrations will be accepted. The Editorial Board reserves the right to limit the number and size of illustrations used with any manuscript submitted for publication. The author is responsible for any charges in the preparation of zincs and half-tones from illustrations.

REPRINTS

Reprint order blanks with a schedule of prices will be attached to galley proofs. Individual reprints of an article must be obtained direct from the author.

COPYRIGHT

Matter appearing in the ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION is covered by copyright. Permission for reproduction must be directed to the Editorial Board.

Detailed information covering instructions for the preparation of manuscripts for publication may be had by writing direct to the Editorial Office, 30 N. Michigan Ave., Chicago 2.

Printed in U.S.A.

MEAD HOME TREATMENT STIMULATOR

Interrupted Direct (Galvanic) Current

For Prolonged Electrical Stimulation of Denervated Muscle

Patients with peripheral nerve disorders who could benefit from daily electro-therapy often get only token treatment because of the expense and inconvenience of daily office visits. Here is the answer to this need — intensive treatment.

- ☐ UNDER MEDICAL SUPERVISION
- ☐ AT LOW COST TO PATIENT
- ☐ WITHOUT LOSS OF WORK TIME
- ☐ WITH SIMPLICITY AND SAFETY OF OPERATION

STIMULATORS ALSO AVAILABLE ON A RENTAL BASIS

ST. LOUIS INSTRUMENT ENGINEERING, INC.
1507 S. Compton Avenue, St. Louis 4, Mo.

EXCELLENT OPPORTUNITY

Group desires board-qualified physiatrist for large mid-western city. Full time, salary open. Stimulating opportunity for teaching and research. Write Box CC 13, Archives of Physical Medicine and Rehabilitation, 30 N. Michigan Ave., Chicago 2.

WANTED—PHYSIATRIST: Dipl or elig; head dept, new 170 bd orth hosp now under constr; affil impor med sch; E.
WANTED—PHYSICAL THERAPISTS: (a) Chief; active dept; 275 bd gen hosp; $4800; lge city; MW. (b) Fully apprv'd lge gen hosp; desirable city; Calif. (c) Chief; 350 bd vet gen hosp; twn 50,000; SE. (d) Staff; modern dept; 275 bd teach'g hosp; resort city; SW. (e) Chief; 150 bd gen hosp, apprv'd JCAH; new dept; Texas. (f) For cerebral palsy work; cty hlth dept; Calif. (g) Req'd; dept 85 bd gen hosp & lge, noted clin grp; Pac NW. (i) New & modern dept; gen hosp 250 bds; attrac resort city; MidE. (j) Chief; 2 others in dept; fully apprv'd 350 bd gen hosp; Calif. (k) Staff; 600 treatments pr mo; 200 bd hosp; min $4000; univ twn; MW. (l) Chief; 125 bd gen hosp, expand'g to 250; city 100,000; SW. (m) Req'd; new univ hosp open soon; West. (n) Active dept; cons arthritic cases; apprv'd 150 bd gen hosp; lge univ med ctr; E.
Please send for an analysis form so we may make an individual survey for you. We offer you our best endeavors — our integrity — our 59 year record of effective placement achievement. Strictly confidential. Woodward Medical Bureau, 185 N. Wabash, Chicago.

— *WANTED* —

Registered female physical therapist for pre-school cerebral palsied children. Mobile unit in southeastern Ohio. Therapist with specialized training and experience in field of cerebral palsy preferred. (Scholarship for special training considered for one who lacks same.) Good salary; vacation with pay; station wagon and traveling expenses provided. Forty-hour week. For additional information and application write Miss Grace Roberts, Adm. Director, Cerebral Palsy Treatment Center, 553 E. Town St., Columbus 15, Ohio.

WANTED

Physical Therapist in 17 man Clinic. All Board men. Mid-west area, 90 miles from Chicago. Write Box A-2300, Archives of Physical Medicine and Rehabilitation, 30 N. Michigan Ave., Chicago 2.

OPPORTUNITY

Five-hundred bed general hospital in large southern city has opening for M.D. trained in physical medicine to head well-equipped, air-conditioned Physical Therapy Department. Write Box A-3500, Archives of Physical Medicine and Rehabilitation, 30 N. Michigan Ave., Chicago 2.

OPPORTUNITIES AVAILABLE

WANTED—Physiatrist, direct department, voluntary general hospital, 500 beds, affiliated medical school; South. For further information, please write Burneice Larson, Director, Medical Bureau, Palmolive Building, Chicago.

WANTED—(a) Occupational and physical therapists; relatively new general hospital of 300 beds; air base, California. (b) Occupational therapist; well staffed department, large university; South. (c) Physical therapist; university department of student health; in addition to caring for private patients, duties include teaching course in basic principles of physical therapy in pre-physical therapy course given in college of physical education and health; well staffed department; expansion program; attractive location, South. (d) Chief physical therapist to serve under direction of physiatrist; 500-bed general hospital; building program will increase capacity to 600; large city, university center, Midwest. (e) To join staff of orthopedic clinic operated by group of American Board orthopedic surgeons; resort city, South. (f) To assist two board orthopedic surgeons; New England. (g) Therapist to join staff of county health department; visiting orthopedic surgeon conducts orthopedic clinics and prescribes physical therapy required; suburb, large city, East.

For further information, regarding these opportunities, please write Burneice Larson, Medical Bureau, Palmolive Building, Chicago.

THE MEDITRON

Two-Channel Electromyograph Model 201 AD

FIRST in Quality and Application

Another MEDITRON advancement in versatility and design, affording you the progressive approach to CLINICAL, RESEARCH, and INSTRUCTIONAL Electromyography.

A custom-built instrument
Guaranteed Unconditionally.

Write for information to:

The Meditron Company
708 S. Fair Oaks Ave.
Pasadena 2, California

To keep you posted, Doctor...

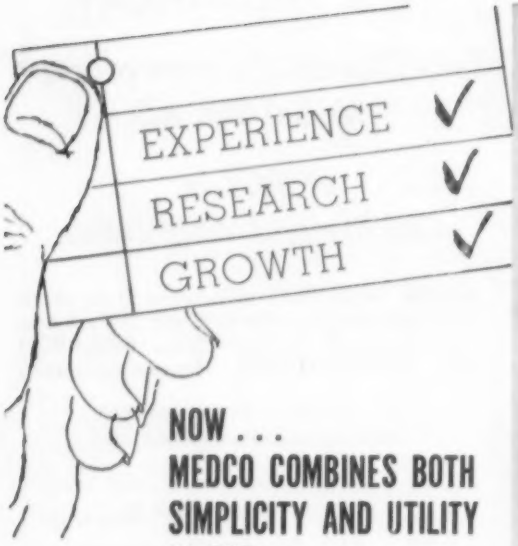
on up-to-date techniques for detecting and treating cancer, we have ● ● ●

● ● ● *in our professional film library, films on nearly 150 subjects covering cancer diagnosis, detection and treatment, available on loan* ● ● ●

● ● ● *our monthly publication, "Cancer Current Literature," an index to articles on neoplastic diseases from American and foreign journals.*

For information about these and other materials, write your state Division of the

American Cancer Society



NOW . . .
MEDCO COMBINES BOTH SIMPLICITY AND UTILITY IN THE

Medcolator®

MODEL K

WITH

RECIPROCAL STIMULATION

$295.00

An adjunct therapy for sprains, strains, dislocations, other trauma of the muscle and skeletal system. The MEDCOLATOR Model K combines the Simplicity of Model 50 with the Utility of Model 50B.

WRITE
For Your FREE
Pad Placement
COLOR CHART
For Wall Hanging

MEDCO PRODUCTS CO.
3603 East Admiral Place • Tulsa, Oklahoma

Medco Products Co.
Mail Address: P. O. Box 3275-A
3603 E. Admiral Pl. • Tulsa, Oklahoma

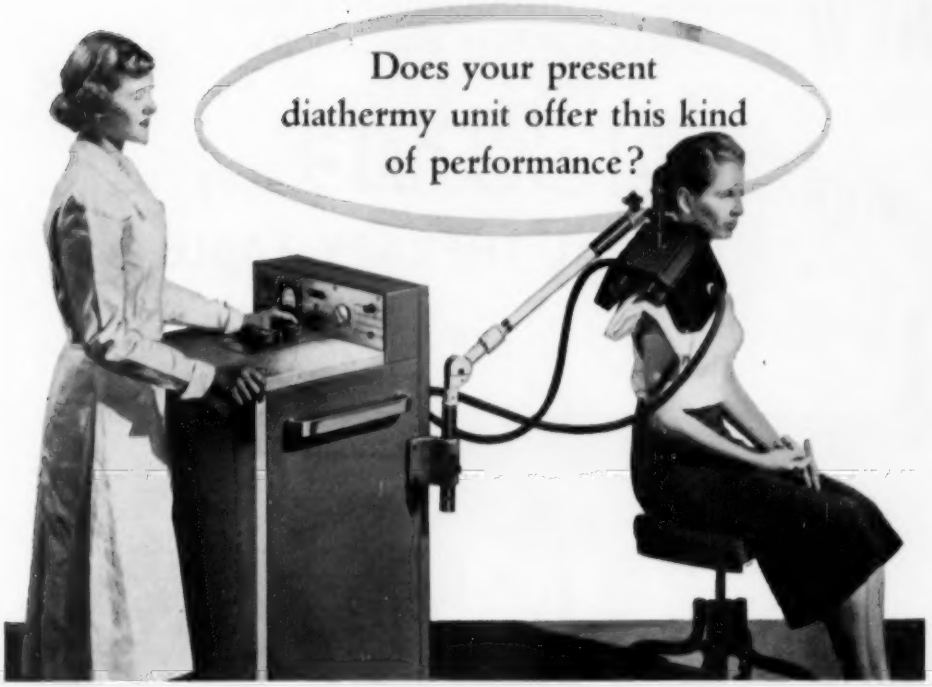
- ☐ Please send Pad Placement Color Chart.
- ☐ Please send MEDCOLATOR Model K with Reciprocal Stimulation for 30 day FREE trial.
- ☐ Please send descriptive literature on MEDCOLATOR Model K.

NAME_____

ADDRESS_____

CITY_____ STATE_____

Serving the Profession Since 1932



13.56 megacycles . . . proved best for induction heating

yours with the G-E F-II Inductotherm®

Results in diathermy are produced by vascular heat — *not* surface heat. That's why General Electric's Model F-II Inductotherm operates at 13.56 megacycles — the proven optimum range for most efficient heating of vascular tissue.

What's more this G-E unit has a rated output of 200 watts — more than enough for all modern technics. And you get built-in reserve for long-life performance.

The versatile General Electric Inductotherm unit lets you handle the complete range of treatments *easily, effectively and safely.*

Get all the facts from your G-E x-ray representative. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. 045.

- Unit features full adjustable contour-following electrode. (Illustrated).
- Optional equipment includes 12-ft. cable electrode . . . fully adjustable, air-spaced condenser-type electrode . . . electrosurgical kit.
- Amplifier tube has high capacity for long, dependable service.
- Crystal oscillator circuit assures consistent operation at approved frequency.
- Controls are simple. Electrodes attach to rear of unit.
- Preset timer automatically ends treatment. For extra safety, convenient switch cord lets patient shut off unit at any time.

Progress Is Our Most Important Product

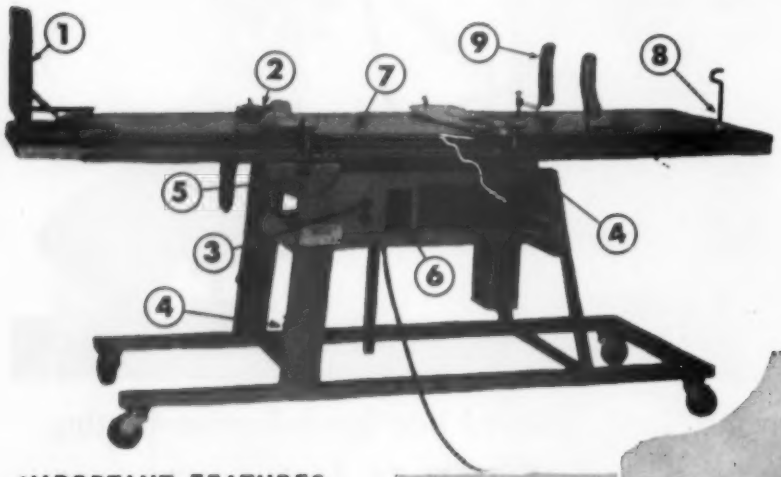
GENERAL ELECTRIC

A — 205

NEW MODERN AID for PHYSICAL THERAPY PATIENTS
BETTER MUSCULAR EVALUATION

La Berne

PHYSICAL THERAPY TABLE



IMPORTANT FEATURES:

1. Adjustable foot board
2. Adjustable restrainer straps
3. Push button switch
4. Safety switches
5. Calibrated dial for degree of tip
6. Receptacles for auxiliary equipment
7. Table top sponge rubber with easy-to-clean plastic cover
8. Adjustable cervical traction holder
9. Adjustable crutch

   Adjustable arm slings

With the LaBerne Table patients can be handled by one attendant. A task that was formerly difficult even for a team. Patients benefit from more effective exercises, added confidence. Write for illustrated brochure to:

Simple push button control adjusts table to any degree of tilt from 0 - 90°.

La Berne MANUFACTURING COMPANY
P. O. Box 5245, Columbia, South Carolina

For Effective Ultrasonic Therapy

The Burdick®

UT-1 ULTRASONIC THERAPY UNIT

● The Burdick UT-1 Ultrasonic Unit provides optimum dosage control plus ease and simplicity of operation.

An audible signal warns the operator when contact is inadequate for effective treatment, and a double scale meter registers intensity and total output. The level of intensity can be pre-set by a push button switch and power control. Timing is automatic.

The applicator, with its very flexible connecting cable, has been designed for convenient application to various parts of the human body. Conforms with F.C.C. regulations.

Detailed information available at
your Burdick Dealer, or write:

THE BURDICK CORPORATION
MILTON, WISCONSIN

ILLE ENGINEERED for efficient, economical service

Combination THERAPEUTIC TANK AND POOL, Model HM 1200 . . . A special stainless steel tank permitting a combination of passive and voluntary exercise with hydro and manual massage, while avoiding the necessity of attendant entering the water.

Combination ARM, LEG AND HIP TANK, Model HM 601 . . . Stationary, stainless steel unit for hydromassage and subequa therapy. Water mixing valve is thermostatically controlled.

LITERATURE ON REQUEST

Hudgins MOBILE SITZ BATH, Model SB 100 . . . For hospital, clinic or office use . . . sturdy stainless steel and aluminum . . . easy to clean and assemble. Electric heater (optional) maintains temperature of solution.

ILLE ELECTRIC CORPORATION
50 MILL ROAD, FREEPORT, L. I., N. Y.

Georgia Warm Springs Foundation
GRADUATE COURSE

Physical Therapy and Occupational Therapy
In the Care of Poliomyelitis

This course is open to graduates of approved schools of physical and occupational therapy. Such graduates must be members of the American Physical Therapy Association and/or American Registry of Physical Therapists, or American Occupational Therapy Association.

Entrance Dates: First Monday in January, April and October.

Course I — Emphasis on care of convalescent neuromuscular disease with intensive training in functional anatomy, muscle testing, muscle reeducation and use of supportive and assistive apparatus. This course is complete in itself.

Course II — Three months duration with course I prerequisite. Emphasis on care of severe chronic physical handicaps with intensive training in resumption of functional activity and use of adaptive apparatus.

In-Service Training Program — Fifteen months duration at salary of $225 per month plus full maintenance. This program includes training in courses I and II.

Tuition: None. Maintenance is $100 per month. For scholarship to cover transportation and maintenance for courses I and II, contact National Foundation for Infantile Paralysis, Inc., 120 Broadway, New York 5, New York. (Scholarships require two years of experience).

For further information contact:

ROBERT L. BENNETT, M.D.
Medical Director
Georgia Warm Springs Foundation
WARM SPRINGS, GEORGIA

CEREBRAL PALSY

Its Individual and Community Problems

William M. Cruickshank, Ph.D.
George M. Raus, M.D., *Editors*

Medical and non-medical specialists bring to the problems the most advanced thinking and latest research data available.

A comprehensive overview of a complicated professional problem with suggestions for solutions. Of special value to physicians, educators, nurses, therapists, and social case workers.

at bookstores or order from

SYRACUSE UNIVERSITY PRESS
Box 87, University Station
Syracuse 10, New York

Analysis of Results of Training 400 A/K Amputees

William J. Erdman II, M.D.
and
Emilie L. Maxwell, M.D.
Philadelphia

Many conflicting ideas exist regarding the efficacy of providing artificial limbs for amputees. It is felt by some that it is economically unsound to provide legs for older age diabetics, either because they will not use them, or will develop further physical difficulty, thereby shortening their productive lives. In order to attain an objective evaluation of this problem, we surveyed all cases of above knee amputees trained in a Department of Physical Medicine and Rehabilitation during a two year period. An attempt was made to ascertain their present status. All of those for whom legs were provided are included in the total number of amputees, whether follow-up was possible or not. This was done since it is an acknowledged fact that those patients with a successful outcome readily respond to questionnaires as well as return for periodic evaluation.

The legs were constructed by eight different prosthetists, using either wood, leather, metal or plastic as the basic material. In the younger age group, (under fifty-five years) approximately one-third of the patients are using suction sockets. However, three-fourths of this series are wearing the least expensive type of conventional legs, equipped with friction knees and pelvic bands. Ninety per cent of the prostheses are made of wood. Each amputee received an average of twenty half days of training. No attempt was made to evaluate the comparative merits of one type leg over another, or of a specific training method. We investigated only the ultimate outcome of some of the patients who are no longer available for study once they have been part of a training center program.

Training Program

The training program followed a routine of stump conditioning, including bandaging, stretching and progressive resistance exercises; balancing on each leg; and progressive ambulation from parallel bars through crutches and canes until the best gait consistent with the patient's capabilities was achieved. This included training on ramps, curbs, steps and public transportation. It is significant that a large number of amputees reverted to some type of assistance, usually a cane and sometimes crutches, when they began walking among groups of people. More than one-half of the patients trained were financed by the Pennsylvania State Bureau of Vocational Rehabilitation. It was necessary to consider employment potentials when providing a limb and training in its use. A much smaller number of prostheses were purchased by the amputees. The smallest number of limbs was purchased by insurance companies.

Table 1: Above knee amputees in study

Total number of above knee amputees	403
Total number with follow-up	203
Total male amputees	315
Total males with follow-up	159
Total female amputees	88
Total females with follow-up	44

50.4 per cent of total number of amputees were studied in follow-up

Consideration of those individuals only who answered questionnaires or who returned for evaluation would present a distorted picture of the results (table 1). Undoubtedly, some died and others found that an artificial leg was more of a hindrance than a help. Those who did not reply are included in the totals of the number of amputees and in the breakdown by causes of amputa-

Read at the Thirty-second Annual Session of the American Congress of Physical Medicine and Rehabilitation, Washington, D.C., September 9, 1954.

Assistant Professor of Physical Medicine and Rehabilitation (Dr. Erdman); Resident in Physical Medicine and Rehabilitation (Dr. Maxwell), Hospital of the University of Pennsylvania, Philadelphia.

tion (table 3), but not in considering results of training, since they could not be classified properly. The same percentage of women and men responded to the follow-up. The overall ratio of those who have had an above knee amputation and go through a training program in a general hospital is probably significant. Naturally, this ratio differs from place to place, according to the type of patients treated.

Table 2: Present disposition of known prostheses

Total number of above knee amputees using prosthesis	193
Total number of above knee amputees not using prosthesis	10
Total number not using prosthesis — living	4
Total number not using prosthesis — dead	6

95.7 per cent of amputees now using prostheses

Of those who responded to this study (table 2), 95.7 per cent are using their prosthesis at present. Six are known to be dead. Three of the discarded legs have been sent to Korea for use by civilian amputees of the recent war, along with other prostheses not in this series and no longer in use by those for whom they were made. The remaining four never learned a satisfactory gait or became dissatisfied with their limbs. One patient developed an ulcer on his opposite foot during training and lost the second leg. He also suffered a dominant sided hemiplegia. However, he is now a satisfactory bilateral amputee and is included in the series. There were seventeen bilateral amputees. Of this number, eleven are known to be doing well. One died from myocardial infarction; the second attack after a clot from a previous episode had produced a saddle embolus resulting in the loss of both legs.

Causes of Amputation

The ratio of causes of amputation in this series should approximate the overall ratio of patients who are suitable candidates for prostheses in any large segment of population (table 3). They were drawn to a general hospital in a metropolitan area.

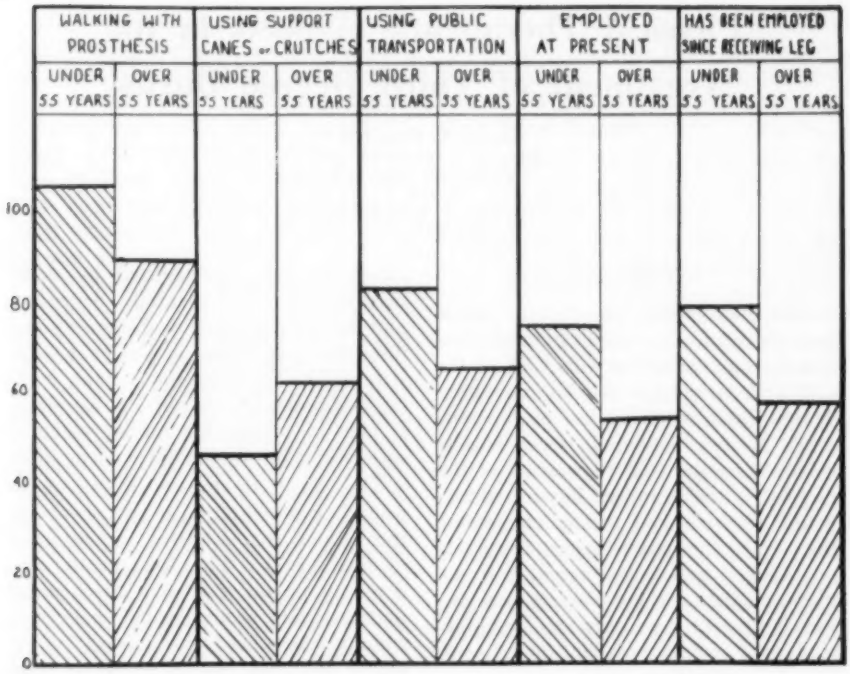
We have not included patients who were such poor medical risks that they could not use legs or those who could not afford to purchase limbs even though from a medical standpoint they could have been considered good risks. Since the vast majority of amputees today are in the middle and older age group of the civilian population, we should not become overly optimistic about the outcome. Instead, it is necessary to be realistic about results in considering the economics of providing artificial limbs. Half of our patients had amputations resulting from arteriosclerosis, with or without diabetes. In view of this, and the results of this follow-up, we are encouraged to believe that this condition need not be a deterring factor in providing limbs.

Table 3

Causes of Amputation	Number of Patients	Average Age
Arteriosclerosis with diabetes	125	57.3
Arteriosclerosis without diabetes	80	62.6
Trauma	97	38.9
Endarteritis obliterans	26	55.0
Emboli	22	47.1
Osteomyelitis	16	43.2
Malignancy		
Sarcoma	9	46.2
Carcinoma	5	54.3
CA secondary to burn	1	19.0
Frostbite	8	57.6
Varicose ulcer	2	44.5
Charcot knee	1	58.0
Hemangioma	1	20.0
Bone cyst	1	30.0
Unknown cause	9	51.0
Total Amputees	403	52.2

Graph of Results

In this graph, the amputees are separated into two groups, and arbitrarily divided at the fifty-fifth birthday. This is the median age and provides a ready demonstration that older amputees do almost as well with prostheses as do the younger ones. "Using support" refers to any help to which the amputee has reverted—from one cane to two crutches. We usually advise that amputees who are to ride on crowded trolley cars carry a cane, so that people will afford them consideration. Possibly, this has led to more assistance than is advisable or necessary. They have been encouraged to return to work as quickly as possible after completion of training. Any degree of success along this line is due largely to the work of the Rehabilitation Counselors from the State Bureau of Vocational Rehabilitation, who follow their clients closely and make contacts regarding work for them.



Two notable observations in this graph are: 1) Approximately eighty per cent of both groups use public transportation consisting of busses, slow and fast moving trolleys, subway and elevated trains, and 2) approximately seventy per cent have been employed and of these, almost all are employed at present regardless of their age group. This figure includes housewives, if they are using their legs and are able to take complete care of their homes.

Summary

An attempt was made to contact 403 above knee amputees referred to a Department of Physical Medicine and Rehabilitation, over a two year period, for fitting and training with prostheses. The 203 who responded to the questionnaire are included. Of these, 95.4 per cent are using their artificial legs; 80 per cent are able to use public transportation; 70 per cent are employed and 46 per cent require no support, such as a cane, in ambulation. In view of the fact that the average age of these patients at the time of fitting with a prosthesis was 52.2 years, and since only one patient developed medical difficulty which could be attributed indirectly to training, it is felt that age is not a deterrent factor in providing above knee amputees with legs which will make them productive citizens.

For reprints, write Dr. Erdman, Director, Department of Physical Medicine and Rehabilitation, Hospital of the University of Pennsylvania, 3600 Spruce St., Philadelphia 4, Pa.

Physical Therapeutic Aspects in the Treatment of Third Degree Burns

Charles S. Wise, M.D.*
Gordon S. Letterman, M.D.
Maxine Schurter, M.D.
and
Jessie E. Fair, R.P.T.
Washington, D.C.

Introduction

The management of severely burned patients requires the application of physical therapeutic technics as well as the skill and knowledge of plastic surgery. Today, total rehabilitation of the seriously burned patient is most readily achieved by the full cooperation of the physiatrist and surgeon. Physical therapeutic methods and plastic reconstructive surgical procedures must be closely coordinated and fully integrated if the ultimate goal for these patients, their return to useful lives of gainful employment and maximum social adjustment, is to be realized.

The necessity for adequate skin covering is obvious, not only for the physiological requirements of the patient, but often for equally important esthetic reasons. It has been our observation that too much attention paid to the local tissue defect with the necessary immobilization of surgery results in less rapid recovery of strength and joint range. The physiatrist's responsibility begins as soon as the patient is hospitalized and does not cease until the patient is returned to a useful social existence. Failure to keep objectives of treatment in proper sequence may result in permanent disability or prolonged hospitalization.

Therapeutic Program

The increased rate of survival of severely burned patients has necessitated the formulation and organization of a new therapeutic program. The total rehabilitation of the individual suffering serious thermal injury constitutes the underlying principle and goal of all treatment. It no longer is enough to save the critically injured, only to have him plagued by painful and infected granulating wounds; immobilized by dense scar contractures; mentally depressed, and socially ostracized by disfiguring and distorted facial features. The goal today is reached only when the patient, without embarrassment or physical handicap, is able to resume his former place in society and pursue a gainful occupation.

The local treatment of the burn wound has concerned physicians throughout the centuries of recorded medical history. The fundamental underlying physiologic and biochemical derangements produced by thermal trauma have been the subject of research and study within recent decades. It is the practical clinical application of this basic physiologic knowledge and the administration of new chemotherapeutic agents which has resulted in the survival of many who only a few years ago would never have lived to receive further medical assistance.

Treatment

The treatment of severe burns has been divided for academic purposes into three phases which lend themselves to the presentation of this discussion. The objectives and problems of combined responsibility encountered during these several periods of care have been clarified by a review of our personal experience in the clinical management of the severe third degree burn cases on the George Washington University Surgical Service.

Read at the Annual Meeting of the American Society of Physical Medicine and Rehabilitation, Washington, D.C., September 7, 1954.

*Professor of Physical Medicine and Rehabilitation, The George Washington University School of Medicine, Washington, D.C.

From the Departments of Surgery (Drs. Letterman and Schurter) and Physical Medicine and Rehabilitation (Miss Fair), The George Washington University Hospital, Washington, D.C.

The initial therapeutic phase is primarily emergency in nature and occupies only the first several hours following injury. At this time a satisfactory respiratory exchange must be obtained; hemorrhage controlled; pain and apprehension abolished. Shock, which is a constant accompaniment of all severe burns, must be treated, and even more important, prevented.

The manner in which these initial emergency life-saving measures are carried out has a very direct bearing upon the final and complete rehabilitation of the patient. A poorly planned and badly executed emergency tracheotomy may unnecessarily complicate the design and surgical transplantation of a cervical flap much needed for the reconstruction of facial features. Of equal significance, a disfiguring and disabling neck contracture may result from a healed vertical tracheotomy scar. A Z-plasty procedure combined with active and passive stretching is required to obtain relief from this annoying condition.

Cervical vessels indiscriminately clamped and ligated may result in irreversible brain and tissue damage. Fluids, ill-chosen or carelessly given, during the shock phase may not only necrose tissue and cripple an extremity, but destroy skin much needed for grafting and subsequent repairs.

The local management of the burned surface during the emergency period varies, but the fundamental principle of open surgical drainage should not be violated. A sterile occlusive pressure dressing with an inner layer of fine meshed gauze may be applied as soon as the individual's general condition permits and adequate materials and assistance are obtained.

Dressings and Positioning

The exposure treatment of burns has been utilized in a limited number of patients during the past three years. The method is applicable to those cases whose burned areas permit complete exposure in any one position. The patient is placed in bed on clean sheets in the most comfortable fashion possible. The burn exudate dries; injury to the crusts or eschars is avoided. Indeed, it is upon the continuity of these surfaces that the prevention of infection and success of the method depends.

The application of dressings and the positioning of the patient treated either by the open or closed method is carried out with great care. Foot and wrist drop, as well as other joint disabilities, may result if proper positioning is not instituted early. Pressure dressings can prove a tourniquet if applied too lightly, and extremities can be needlessly damaged or lost in this manner. Therefore, simple measures taken to assure the optimum possible functional position of all joints, and careful dressings constitute one of the first steps in total recovery of the burned patient.

After systemic derangements have been corrected and dressings applied or exposure instituted, attention is directed toward achieving a closed wound at the earliest possible moment. This is a phase of definitive treatment. Deep burns, which in reality are raw surfaces with a necrotic covering, are debrided. Granulating wounds are cleaned up and prepared for surgery with minimum delay. Skin grafts are applied. Properly prepared broad raw surfaces involving a substantial percentage of body area often can be covered in a single operation by the application of split thickness skin grafts. In other instances the involved surface may be too great and the possible donor sites too limited. Under such circumstances only strategic areas, carefully chosen in relation to the total recovery of the patient, can at first be grafted.

The attainment of these objectives during the second therapeutic phase is aided by daily physical medical procedures; these should be initiated as soon as is practicable after the emergency period. The grafting of large granulating burn wounds is a major undertaking. Many extensively burned patients require three or four skin grafting operations, with the associated anaesthesia, blood loss, and deconditioning incident to major surgery. The physiatrist and

plastic surgeon should cooperate in planning the time of each operation with respect to the patient's overall rehabilitation. In our experience, hospitalization is greatly lengthened and the final results less successful if the surgery is carried out before the burned individual is placed on a reconditioning and rehabilitation regime (chart 1).

Physical Therapy Procedures

The Hubbard tub and whirlpool baths, with their agitators, are employed as an adjunct and often as a substitute for surgical debridement. They also help

Chart 1: Program of rehabilitation for a third degree burn patient. Major surgical procedures, physical training and self-care activities carefully correlated.

Patient: B. C.
Age: 55

Admitted to hospital February 1, 1954 DIAGNOSIS: Third degree burns, involving both upper and both lower extremities, chest, back (more severe in lumbosacral region) and buttocks.
Discharged from hospital June 25, 1954

DATE	OPERATION	REHABILITATION STATUS
February		Passive and active assistive exercises. (Extremities, head and trunk)
March 1	Debridement of burns	Hubbard tub daily for stretching exercises.
March 17	Graft to right arm	Exercises on right arm discontinued.
March 25		Arm exercises resumed. Ambulation in parallel bars begun. Use of wheelchair, rather than stretcher, instituted.
April 5	Graft to right elbow	Exercises on arms discontinued. Increased strengthening exercises for lower extremities.
April 19		Strengthening arm exercises resumed. Arm whirlpool added. Ambulation increased to include stair climbing.
April 30	Graft to right side	Encouragement in self-care activities.
May 26	Graft to right axilla	Ambulation instruction completed. Application of cocoa butter to grafts followed by stretching.
June 25		Patient discharged with instructions in home program for stretching and exercises.

Fig. 1 — Third degree burn patient in Hubbard Tank. Agitators used as an adjunct and aid to surgical debridement.

to preserve the cleanliness of the denuded areas (fig. 1), and have great usefulness in the removal of dried and clotted dressings, debris and infected necrotic areas. This allows for better drainage. The temperature of the water bath is important in the treatment of the severely burned patient, particularly when the more sensitive areas, such as the axillae, groin or flexor surfaces of the extremities are involved. It has been our experience that patients tolerate these procedures better if the water is maintained at slightly below normal skin temperature and gradually increased to tolerance. For the Hubbard tank, about 94-96 F. is optimum initial temperature where full immersion is required, and 92-98 F. where a single extremity is immersed. A greater range of temperature is tolerated when only one or two extremities are immersed, as compared to full body immersion.

Assistive active motion gradually can be increased within limits of pain until maximum active range is achieved. Careful note of the patient's temperature curve may indicate whether daily or less frequent treatments are required.

Occasional spiking of temperature six to twelve hours after hydrotherapy in the severely burned patient has been noted. This may be attributed to the introduction of pyrogenic proteins or bacteria into the circulation as a result of motion of the affected parts underlying the burned areas. It is well known that the temperature controlling mechanisms are disturbed where large areas of the skin covering are denuded. Despite these factors, a low grade spiking fever does not in itself contraindicate early hydrotherapy where antibiotics are available to the patient.

Training in such simple devices as postoperative turning from side to side in bed may make for patient comfort, boost morale and aid in professional care. Whenever possible, bed exercises, more complex self-care activities, and even ambulation, are prescribed before major skin grafting is carried out (fig. 2).

Active range of motion exercises are continued early in the interim between multiple operations. Passive or active stretching exercises are instituted in areas where granulating tissue causes limitation of joint range. Ambulation again is encouraged and all self-care activities are resumed.

In the later stages of healing and convalescence, graded increasing frictional massage assists in prevention of the tight contractures so frequently seen in poorly treated cases. Massage not only prevents the tight fibrotic adhesions, but improves

Fig. 2 — Ambulation of patient shown in figure 1 during interval between skin grafting procedures.

Fig. 3A — Marked contracture and granulating areas of axilla replaced by skin grafts.

Fig. 3B — Complete use of shoulder after grafting and physical therapy. Rehabilitation is complete.

the circulation to newly transplanted or regrowth epithelium. Patients can be instructed in many of these simple procedures.

In the final reconstructive phase, late contractures and deformities are corrected and features restored. Exercise, of gradually increasing resistance, as well as functional activities, is the ultimate program of therapy after the patient is able to leave the hospital. The restoration of a full range of motion and total rehabilitation goals are completed (fig. 3a, 3b).

Summary

In brief, physical therapeutic measures not only help to prepare the badly burned patient for skin grafting, but maintain physical status during the period before surgery and the intervals necessary to multiple procedures. They aid greatly in the restoration of function following both definitive and late reconstructive surgery. It cannot be too strongly emphasized that complete therapeutic success and total rehabilitation of the severely burned patient are most rapidly and effectively achieved through the full cooperation and close coordination of the physiatrist and plastic surgeon.

For reprints, write Dr. Wise, George Washington University Hospital, 901 23rd St., N.W., Washington, D.C.

References

1. Wise, Charles S., and Letterman, Gordon S.: Coordination of Plastic Surgery and Physical Medicine in the Paraplegic Patient. Arch. Phys. Med. & Rehab. 30:616 (Oct.) 1953.
2. Byars, Louis T., and Letterman, Gordon S.: The Local and Systematic Effects of Chronic Ulcerations. Surg., Gynec. & Obstet. 89:583 (Nov.) 1949.
3. Letterman, Gordon S., and Brown, James Barrett: Plastic and Reconstructive Surgery in Cyclopedia of Medicine, Philadelphia, F. A. Davis Company, 1948, pp. 790-819.

An Electromyographic Study of Some of the Muscles Used in Respiration

George H. Koepke, M.D.
Alma J. Murphy, Ph.D.
James W. Rae, Jr., M.D.
and
David G. Dickinson, M.D.
Ann Arbor, Mich.

Introduction

Controversial findings have been published by several investigators[1] seeking to determine the function of muscles used in breathing. Their conclusions were made from observations on physical examination, electrical stimulation and fluoroscopy of human and animal subjects. The study reported here was stimulated by an interest in utilizing electromyography as a method for evaluating the function of some muscles used in normal respiration.

Electromyographic studies[2,3] of the thoracic and abdominal muscles have been carried out recently by means of surface electrode technics. After a preliminary study using surface electrodes, the present investigation was made by inserting needle electrodes into the intercostal, pectoral, sternocleidomastoid, serratus anterior, rectus abdominis, external and internal oblique muscles.

Methods

Apparatus: The instruments used in this study were designed to determine the activity of some of the muscles of respiration during quiet and maximal breathing. The electrical activity was studied with an electromyograph and chest expansion was recorded with a pneumograph. The action potentials were recorded by a single channel electromyograph. A two-inch unipolar needle insulated to within approximately 0.4 mm. of the tip was used. Small needles used in electroencephalography were used as reference and ground electrodes. The pneumograph cuff was attached to a pressure transducer, Brush D-C amplifier, and magnetic pen recorder. Proper shielding was provided to eliminate interference with the electromyograph.

Procedure: Subjects for this study were forty-five normal males between the ages of twenty-two and thirty years. Samples were taken from either side of the neck, chest, and abdomen in supine, sitting, and standing positions. When the subjects were supine, their heads were resting on a pillow and their arms and legs were comfortably extended. Those seated erect had their arms, back, and head supported in a relaxed position. A few individuals were tested in an unsupported standing position.

After each subject was positioned, the pneumograph cuff was placed about the chest at the nipple line. In sampling the muscles of respiration, the reference needle electrode was placed within six centimeters of the point of insertion of the insulated active needle electrode. The ground electrode was inserted at any convenient location. Care was taken to minimize infection at the site of insertion of the searching electrode by cleaning the skin and needle with aqueous zephiran. The reference and ground electrodes were prepared with seventy per cent alcohol. No form of anesthesia was used in these experiments.

To insure the limitation of activity to the muscles being sampled, the subjects were asked to perform specific movements that would cause either that particular muscle or adjacent muscles to contract. For example, the procedure used to test the upper intercostals is shown in figure 1. The needle was inserted at the second intercostal space into the pectoralis major. The subject was then asked to adduct the arm, caus-

Read at the Thirty-second Annual Session of the American Congress of Physical Medicine and Rehabilitation, Washington, D.C., September 8, 1954.

From the Departments of Physical Medicine and Rehabilitation (Drs. Koepke, Murphy, and Rae), and Pediatrics and Communicable Diseases (Dr. Dickinson), University of Michigan Medical School, Ann Arbor, Mich.

Fig. 1 — Application of the pneumograph cuff and insertion of the needle electrodes for sampling the activity of intercostal muscles.

ing large action potentials to be generated. If the needle had been inserted deeper into the pectoralis minor, smaller voltages and more distant activity would have been observed. When the needle was in the pectoralis minor, distinct action potentials were noted on protraction and depression of the shoulder. The needle encountered resistance at the clavipectoral fascia before passing through the pectoralis minor. When the needle entered the intercostal muscles, rhythmical activity was noted with inspiration and expiration. To insure that the large action potentials being observed were originating from the intercostals and not from the pectoralis minor, the subject was asked to protract and depress the shoulder. If action potentials were recorded by this maneuver, it was immediately recognized that the needle tip was in the pectoralis minor.

Separate observations were made of the activity of several muscles of respiration. These include the upper and lower intercostals, pectoralis major, pectoralis minor, sternocleidomastoid, serratus anterior, latissimus dorsi, rectus abdominis, external oblique and internal oblique. Various segments of these muscles were examined as shown in figure 2.

Initial tests were made on each muscle until it was determined that the individual was breathing quietly. Rhythmical and minimal excursions of the chest were recorded by the pneumograph when the subject appeared to be relaxed, free from pain, and breathing without effort. When this pattern of respiration continued for more than two minutes, notations were made of the electromyographic activity. Additional observations were made when the subject was asked to inhale and exhale maximally in his usual manner. If good activity were observed, the patient was asked to discontinue his maximal breathing to avoid trauma by excessive movement of the tip of the needle on surrounding structures.

Results

The data given in figure 3 summarize

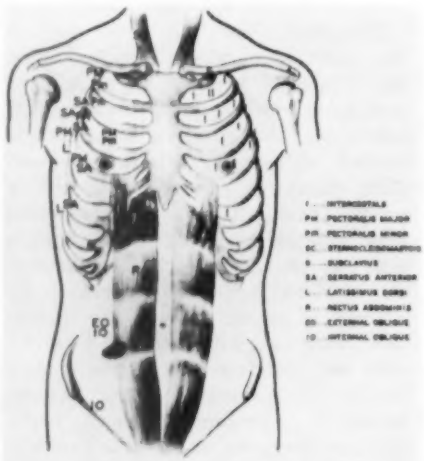


Fig. 2 — Location of the active needle electrode in the various muscles sampled for respiratory function.

MUSCLE TESTED	NUMBER OF SUBJECTS	NO. OF SUBJECTS SHOWING ELECTRICAL ACTIVITY			
		Quiet Breathing		Maximal Breathing	
		Inspir.	Expir.	Inspir.	Expir.
1st Intercostal Inner	1	1	0	1	0
Middle	3	3	0	3	3
Outer	2	2	0	2	2
2nd Intercostal Inner	1	0	0	1	1
Middle	3	0	0	3	3
3rd Intercostal Middle	8	0	0	8	8
Outer	4	0	0	4	4
4th Intercostal Middle	1	0	0	1	1
Outer	5	0	0	5	5
5th Intercostal Outer	3	0	0	3	3
6th Intercostal Outer	8	0	0	8	8
7th Intercostal Outer	1	0	0	1	1

Fig. 3 — Activity of the intercostal muscles, subjects in supine position.

MUSCLE TESTED	NUMBER OF SUBJECTS	NO. OF SUBJECTS SHOWING ELECTRICAL ACTIVITY			
		Quiet Breathing		Maximal Breathing	
		Inspir.	Expir.	Inspir.	Expir.
Pectoralis major Clavicular	6	0	0	4	5
Sternal	11	0	0	3	6
Pectoralis minor	10	0	0	10	0
Sternocleidomastoid	9	0	0	9	0
Serratus anterior 3-4 ribs	4	1	0	3	4
5-7 ribs	6	0	0	6	6
Latissimus dorsi	2	0	0	1	2
Rectus abdominis	15	0	0	0	9
External oblique	10	0	0	0	9
Internal oblique Inguinal lig.	9	0	0	4	9
Right Upper Quadrant	3	0	0	1	3

Fig. 4 — Activity of the shoulder girdle and abdominal muscles, subjects in supine position.

the results of the examination of the muscles with the subject in the supine position. In all instances only the first intercostal muscle was active in quiet inspiration. All intercostals were inactive during quiet expiration with one exception; one sample of the sixth intercostal muscle revealed slight contractions on quiet expiration. All intercostals were used for deeper inspiration and expiration. Due to the difficulty in accurately locating the tip of the needle, the functions of the external and internal intercostals could not be differentiated.

The other muscles sampled in a supine position are shown in figure 4. None were used for quiet breathing with the exception of minimal activity of the serratus anterior in one subject. In all instances, the pectoralis minor and the sternocleidomastoid were used for deeper inspiration and were inactive during maximal expiration.

The pectoralis major was used during maximal inspiration in seven of seventeen subjects and during maximal expiration in eleven. The serratus anterior was used during maximal inspiration in nine of ten subjects and ten used it during maximal expiration.

No activity was recorded from the rectus abdominis in quiet breathing or maximal inspiration. It was used during maximal expiration in nine of fifteen subjects. The external and internal abdominal obliques were used in five of twenty-two subjects for maximal inspiration. They were active during maximal expiration in twenty-one of twenty-two subjects.

The results of a study of the muscles sampled in the sitting position are shown in figure 5. In this position, activity was found in some subjects in the second and third intercostal muscles as well as the first intercostal space during quiet inspiration. In quiet expiration, three of six samples revealed slight activity in the second and third intercostal muscles. All of the intercostal muscles tested were functioning on maximal inspiration and maximal expiration, except in one subject who did not use the first three intercostals during maximal expiration but did use the fourth intercostal muscle.

While the subjects were seated, the pectoralis major, pectoralis minor, rectus abdominis, and external oblique were inactive during quiet respiration. The pectoralis major and the rectus abdominis

MUSCLE TESTED	NUMBER OF SUBJECTS	NO. OF SUBJECTS SHOWING ELECTRICAL ACTIVITY			
		Quiet Breathing		Maximal Breathing	
		Inspir.	Expir.	Inspir.	Expir.
1st Intercostal	2	2	0	2	1
2nd Intercostal	4	2	2	4	3
3rd Intercostal	2	1	1	2	1
4th Intercostal	4	0	0	4	4
5th Intercostal	3	0	0	3	3
7th Intercostal	1	0	0	1	1
Pectoralis major	5	0	0	0	3*
Pectoralis minor	2	0	0	2	0
Rectus abdominis	6	0	0	0	4
External oblique	5	0	0	3	4
Internal oblique	5	3**	3**	4	5

* All subjects set their shoulders.
** Continuous activity.

Fig. 5 — Activity of some of the muscles of respiration, subjects in sitting position.

were not used during maximal inspiration. In maximal expiration, the pectoralis major was used in three of five subjects and the rectus abdominis in four of six subjects. The pectoralis minor was active during maximal inspiration in the two subjects examined. Of the five subjects studied for activity in the external oblique muscle, three showed activity during maximal inspiration and four during maximal expiration. Continuous activity of the internal oblique above the inguinal ligament was observed in three of the five subjects sampled in the sitting position. Four of the five subjects demonstrated increased activity in the internal oblique muscle during maximal inspiration. All five subjects showed activity during maximal expiration.

Attempts were made to examine the abdominal muscles of several subjects in the standing position. However, since several patients became faint, sufficient data could not be obtained.

Discussion

A preliminary study was made with the surface electrodes on some of the muscles of the chest and abdomen in nineteen subjects. This method was convenient and atraumatic but did not yield dependable data because the source of the action potentials could not be localized. When a skin electrode was placed over the pectoral region, similar action potentials were observed with varied movements of the shoulder, as well as with inspiration and expiration. Therefore, in order to distinguish the action of adjacent muscles, the insulated needle technic was found to be more satisfactory.

The muscles sampled with the needle technic were selected arbitrarily and do not comprise all of those described as muscles of respiration. The diaphragm was not sampled for practical reasons. Thirty-three subjects were examined for intercostal activity. Of this group, the pulmonary pleura in two individuals was accidentally penetrated. Each incident resulted in a minimal pneumothorax that spontaneously resolved.

In this study most of the intercostals were used during maximal breathing and only the upper intercostals were active during quiet breathing. Therefore, it appears that recruitment of the lower intercostals occurs as deeper breaths are taken.

Campbell[4] observed activity of the rectus abdominis at the end of inspiration and during expiration. The present investigation of the rectus abdominis revealed slight contractions during or at the end of deep expiration. During inspiration, the external and internal abdominal obliques were inactive. Occasionally, they became active at the end of maximal sustained inspiration when the subject was supine. During maximal expiration the abdominal obliques contracted vigorously. The present evidence would indicate that the abdominal muscles play a more important role in expiration than in inspiration and that the obliques are more effective than the rectus abdominis in producing the expiratory reserve.

A study of the muscles of the shoulder girdle by Inman[6] indicated that some of these muscles act to stabilize the shoulder. It appears from the present investigation that some of the muscles originating about the shoulder and attaching to the rib cage might also act synergistically as muscles of respiration when the shoulder is stabilized.

Summary

Electromyographic investigations were made of the activity of some of the muscles of respiration. Needle electrodes were inserted into the intercostal, pectoralis major, pectoralis minor, sternocleidomastoid, serratus anterior, rectus abdominis, external and internal abdominal oblique muscles. The electrical activity was recorded during quiet and maximal breathing. Samples were taken from either side of the neck, chest, and abdomen of forty-five normal adult males in the supine, sitting and standing position.

The insulated needle technic was found to be a more satisfactory method of determining the action of some of

the muscles of respiration than that of the surface electrode technic.

The first intercostal muscle and diaphragm was used in quiet breathing. Expiration occurred passively. Additional intercostal muscles were recruited during deeper breathing. Difficulty was encountered in distinguishing the action of the internal from the external intercostal muscles.

The muscles of the shoulder girdle were used by some individuals at the end of maximal inspiration and expiration.

The abdominal muscles were more active during expiration than inspiration. The abdominal oblique muscles were consistently used to a greater degree than the rectus abdominis during maximal expiration.

For reprints, write Dr. Koepke, University Hospital, Ann Arbor, Mich.

References

1. Duchenne, G. B.: Physiology of Motion, Philadelphia, J.B. Lippincott Co., 1949.
2. Floyd, W. F., and Silver, P.H.S.: Electromyographic Study of Patterns of Activity of the Anterior Wall Muscles in Man. J. Anat. 84:132, 1950.
3. Jones, D. S.; Beargie, R. J., and Pauly, J. E.: An Electromyographic Study of Some Muscles of Costal Respiration in Man. Anat. Rec. 15:328 (Feb.) 1953.
4. Campbell, E. J. M.: An Electromyographic Study of the Role of the Abdominal Muscles in Breathing. J. Physiol. 117:222, 1952.
5. Inman, V. T.; Saunders, J. B., and Abbott, L. C.: Observations on the Functions of the Shoulder Joint. J. Bone & Joint Surg. 26:1 (Jan.) 1944.

Psychogenic Rheumatism

Edward W. Lowman, M.D.
New York City

Psychogenic rheumatism is an often-encountered and frequently misdiagnosed syndrome among patients presenting themselves with the complaint of "arthritis." Among patients seen in general arthritis clinics, incidences of psychogenic rheumatism have been reported ranging from fifteen to forty per cent. Because of the magnitude of the problem and the generally good prognosis as compared to the organic arthritides and because most eventually come into the hands of physiatrists for treatment, it is important that the syndrome be clearly appreciated.

Definition

Psychogenic rheumatism is a muscular response to the stress of emotional tensions and physiologically, is probably a manifestation of muscular fatigue. It is, therefore, a functional rather than an organic process and is unrelated to the organic arthritides. It may occur as a functional overlay concurrent with organic arthritis, but it occurs alone with such preponderant frequency that, as a rule of thumb, the diagnosis of psychogenic rheumatism usually rules out the presence of an organic arthritis process. Because of the totally different approaches to therapeutic management, the two should be sharply delineated in the early differential diagnosis.

Etiology

It is a well-established fact that the muscular system is frequently the expression level for the emotions. Recent studies of the effects of emotional stress have shown greatly increased oxygen consumption by the brain during periods of anxiety or apprehension. The corollary assumption that increased muscle tone secondary to emotional stress entails a similar increase in metabolic needs and readier fatigue of muscles is hypothetical but generally suspected. Increased muscle tone as the result of emotional stresses is a normal physiological response of the vegetative system,

Read at the Annual Session of the American Society of Physical Medicine and Rehabilitation, Washington, D.C., September 7, 1954.
Clinical Director, Institute of Physical Medicine and Rehabilitation, New York University-Bellevue Medical Center, New York.

so long as this vegetative response is mobilized intermittently in fear, anger, and other normally transient emotional reactions. When the muscular system is called upon for sustained reaction, the result is a dysfunction of the responding system; psychogenic rheumatism is the result. This is one of the group of abnormal vegetative responses termed Vegetative Neuroses. Ruesch[1] has pointed out that these vegetative or visceral neuroses are manifestations of an infantile personality. Such persons are unable to dispense emotional tensions through adult interpersonal relationships and other mature vents, and as a consequence, suffer the cumulative effects of this closed system viscerally. Such visceral expression stems deep into the development system of the psyche and is far more refractive to treatment than more mature conversion mechanisms. The patient with psychogenic rheumatism is thus usually the tense, anxious, nervous individual with or without dynamicism whose psyche is deeply scarred from previous and persisting traumata.

Incidence

Statistically, Hench and Boland found that of 1000 consecutive patients admitted to the Army Rheumatism Center at Hot Springs (Ark.) during World War II, twenty per cent had psychogenic rheumatism.[2] In another series of 450 cases, Boland[3] reported that one-third presented psychogenic disorders. Halliday[4] noted a forty per cent incidence among another group. In the light of this high incidence and in view of the psychological roots of the problem, early diagnosis and proper management assume paramount importance if the patient is to be salvaged from an even more deeply-rooted neurosis and disability.

Differential Diagnosis

Like other functional disorders, psychogenic rheumatism presents no pathological findings demonstrable histologically, roentgenologically, or by other laboratory methods. Similarly, physical examination reveals no related objective findings. The disorder is totally a subjective one.

In establishment of diagnosis the one condition which poses a troublesome question in differentiation is fibrositis. While some writers categorize fibrositis broadly into two types, primary and secondary, there is growing support for restricting its use. Fibrositis is an inflammatory process involving the fibrous constituents of muscle. One rheumatologist prefers to think of this fibrositic process as the smoke signal from the fire of an underlying systemic disease process, whether the latter be clinically identifiable or not. We agree with him in this restricted use of the diagnosis and because of the serious implications of the diagnosis prefer not to minimize its prognostic inferences by associating it with the waste-paper basket of entities usually called primary fibrositis. The differential diagnosis then rests between psychogenic rheumatism and secondary fibrositis of obvious or obscure etiology.

If the underlying systemic process accounting for the fibrositis is clinically apparent, such as rheumatoid arthritis or lupus erythematosus or chronic gouty arthritis, there is no problem in diagnosis. It is in those cases of true fibrositis without objective clinical findings that differentiation from psychogenic rheumatism requires more astute diagnostic acumen. Hench[5] has described the fibrositic patient as the victim of the external environment (weather, heat, cold, rest, exercise, etc.) as contrasted to the psychogenic rheumatism patient whose symptoms fluctuate with changes of the internal environment (mood changes, pleasure, excitement, worry, fatigue, etc.).

The patient with true fibrositis presents a typical clinical picture. The muscle discomfort is of a jelling character worse after any period of inactivity. Consequently, the patient is most disturbed at night when at rest. There is no difficulty in getting to sleep but after one, two or three hours of rest, sleep is interrupted by the aching of inactive jelled muscles. Moving about gives temporary relief and the patient falls off to sleep again only to awaken repeatedly

thereafter through the night. In the morning, the aching is pronounced and prompts the patient to crawl out of bed so that he may move about and "warm up." This limbering-up period may extend into the middle of the day or require only part of an hour. With continued activity through the day, the patient feels progressively less achy and towards evening and night is most free of symptoms. Prolonged sitting during the day produces jelling and symptoms and the patient is unable to sit comfortably through a movie or the like. With barometric changes of the weather or exposure to the cold of drafts, or air conditioning, there is accentuation of symptoms. Salicylates invariably provide some relief.

Conversely, the psychogenic rheumatism patient presents quite a different clinical picture. While this patient may have some morning stiffness, it is not true jelling prompting the patient to be up and out of bed for comfort; on the contrary, it is more of a fatigue stiffness and tiredness and the patient would just as soon remain lazily in bed. This morning stiffness dissipates quickly with the mounting pressure and tempo of the morning. As the day proceeds, however, muscle aching accrues in direct measure with the tensions and pressures of the day and by afternoon the patient is most aware of his pains. There may be some restlessness and difficulty in getting to sleep but once asleep the patient sleeps soundly through the night. Weather has no effect nor does cold, and salicylates are less effective than in fibrositis.

Clinically, psychogenic rheumatism may produce muscle aching and stiffness in localized areas but more often involvement is disseminated. Frequently the muscle pains are migratory and bizarre in distribution. The upper spine, especially the occiput, the cervical and the dorsal regions most commonly are symptom sites but any area may be involved.

Treatment

Psychogenic rheumatism may be acute in onset or it may develop insidiously as a chronic process. The acute syndrome usually follows in the wake of overwhelming and unusual stress. In a mild degree this has probably been experienced by most persons in the exhaustion following family emotional crises, difficult interviews, examinations, etc. With the removal of the precipitating emotional stresses, the muscular system is released from tension and the visceral symptoms dissipate. Understanding by the patient of the underlying mechanism causing the muscular symptoms is important lest the patient's concern over the "rheumatism" add further emotional stress to the system. The definitive approach to treatment obviously is the alleviation or elimination of the psychic stresses while palliatively treating the distressing subjective symptoms.

The chronic process constitutes a more complex treatment problem. In every instance, however, it is imperative that a warm physician-patient relationship be established if the patient is to be supported psychologically in his efforts to gain insight and adjustment to his problem. The average case when first seen usually will have learned by experience the noxious effect of emotional stresses and tensions even though he may not have intellectually accepted a cause-result relationship. The problem always rises as to the advisability of psychotherapy. One psychiatrist has wisely said: "Don't take the lid off until you know what's in the pot; a monster may jump out that can't be got back in." Psychoanalysis and psychotherapy too glibly have come to connote cure of mental ills, and in some quarters there is strong feeling that a good five-cent psychiatrist would cure the world of its ills. Clear-thinking psychiatrists are well aware of this misconception and do not concur. It has been pointed out by them that mental illnesses are not all-or-none propositions, that the reversibility of mental difficulties depends largely upon the depth of their roots and that psychopathologic changes may be as intractable as a stenosed aortic heart valve or a sclerosed renal glomerulus. Appreciation of

this is imperative for a reliable estimate of a patient's situation. Ruesch points out that the treatment of the infantile personality as seen in psychogenic rheumatism is actually child psychology for a chronologically adult person and that therapy is a protracted undertaking in an endeavor to effect maturity. Such an individual has not regressed from a mature to a less mature state of reaction but is exhibiting a facet of his personality that has not matured. Not only must he develop insight into his immaturity, but he must then be helped to grow and develop adult reaction mechanisms much as a child is helped in its progress towards a mature mind. It does not seem logical, then, to subject a patient to such psychiatric upheaval so long as he is a compensated and functioning unit of society. The wiser approach is probably a superficial supportive one for the palliation and understanding of his discomfort. In these cases, it is helpful to give the patient some insight into his difficulty by acquainting him with neuromuscular functional interrelationships and the consequences of emotional tension; the use of such commonly recognized analogies as tension headache, nervous indigestion, and, spastic colitis renders this explanation of psychogenic rheumatism more tenable. In accepting this tension relationship, he accepts the personal responsibility for his difficulty and cannot transfer hopes for cure to the physician. Supportive assurance that much can be done in a palliative way should then be extended and discussed. This entails adoption of a program of physical therapy, sedatives, salicylates, extra rest, and a plan for avocational outlets. Of no small importance is the fostering in the patient of an insight which no longer tolerates fear of crippling or extension of the process. On such a program many patients will stabilize satisfactorily and will learn to adapt to their personality penalties through the use of these palliative crutches.

In a small percentage of cases the immaturity and neurosis will be so profound that the patients will be incapacitated from their psychogenic rheumatism. The prognosis for these patients is extremely poor. Insight is not readily instilled nor accepted and the patient presents himself as a refractory functionless unit. The psychotherapeutic approach here is the only productive one; the aim need not and probably should not be directed towards maturing the infantile individual, but rather the effort should be towards effecting adequate insight for compensation to a functionally useful level. Though this is more readily said than done, it is nonetheless the sole recourse for salvaging these psychosomatic cripples.

Palliative physiotherapeutic measures consist of various heat modalities, massage, and, hydrotherapy. These are valuable for their relaxant effect. Any source of heat may be used. Choice in the individual case should depend upon the desired extent of application, the patient's general physical state, and his response to particular types of therapy. Since physical therapy is totally palliative and an indefinite treatment undertaking, the simplest measures possible should be prescribed. Usually, the simple procedures are as effective as the more intricate, and a patient may realize as much benefit from a contrast shower in his own home as from an expensive steam bath in a professional office or at a health spa. The patient with insight may be instructed to carry out these measures at home with a minimum of economic burden. Professional physical therapy treatment at infrequent intervals but on a maintenance basis may at times be indicated. Intensive courses or indefinite periods of physical therapy are contraindicated unless finances are of no consideration and the strictly palliative goal is appreciated. Salicylates, aspirin, or commercial variants of these are generally the most helpful medication and should be used liberally. Vacations, relaxed work programs, relaxation through hobbies and a greater pursuit of avocational activities are desirable adjuncts. These, unfortunately, are easily prescribed but difficult to initiate into a patient's mud-

dled life situation.

Prognosis

Prognostically, the outlook in psychogenic rheumatism is functionally good but symptomatically bad. Most patients fall into the chronic, non-disabled category; with proper management these patients usually can acquire some insight into their problem, learn methods of relieving symptoms, and so come to live with their disability. Few acute cases are seen who require treatment, probably because the overwhelming triggering stresses are self-limited and permit early remissions. The profound and chronically incapacitated patients are the most complex and require psychiatric care. As with any other deep-seated psychosomatic disorder, the prognosis for these is proportionately poor.

For reprints, write to Dr. Lowman, 400 E. 34th St., New York City.

References

1. Ruesch, Jurgen: The Infantile Personality. Psychosom. Med. 10:134, 1948.
2. Hench, P. S., and Boland, E. W.: The Management of Chronic Arthritis and Other Rheumatic Diseases Among Soldiers of the U. S. Army. Ann. Int. Med. 24:808, 1946.
3. Boland, E. W.: Arthritis and Allied Conditions in an Army General Hospital. California Med. 60:7, 1944.
4. Halliday, J. L.: The Concept of Psychosomatic Rheumatism. Ann. Int. Med. 15:665, 1941.
5. Hench, P. S.: Differentiation Between Psychogenic Rheumatism and True Rheumatic Disease. Postgrad. Med. 1:460, 1947.

Effect of Posture and Local Pressure on Venous Circulation Time of the Leg

Harry T. Zankel, M.D.
R. A. Shipley, M.D.
and
R. E. Clark, B.S.
Cleveland

In a previous publication[1] the effects of various physical modalities on venous circulation time in the leg were described. The present report is concerned with the influence of certain mechanical factors such as elevation or depression of the limb, localized popliteal pressure, and constriction of the calf.

Methods

Patients referred to the Department of Physical Medicine for routine diagnosis and treatment were used as test subjects. Selection was not based on the presence or absence of circulatory disorders of the lower extremities.

As in the previous studies[1], radioiodine (I^{131}) was used as the tracer material. The dose was five microcuries contained in a volume of 0.5 ml. Time for completion of the injection was less than one second. Prior to an injection and during intervals between successive tests, a 20 gauge needle inserted into the dorsal vein of the foot was kept patent by a continuous drip of saline solution flowing at a rate of sixty drops per minute. During the performance of a test the saline was temporarily stopped by means of a two-way stopcock. The test material was injected through the side inlet.

The detecting device consisted of a scintillation counter[2] placed in contact with the skin over the groin at the sapheno-femoral junction. Collimation was provided by a lead window one and one-half inches in diameter and one and three-eighths inches in length. Graphic records were obtained with an Esterline-Angus recorder connected to a rate meter with a time constant of 0.5 second. The time interval recorded ex-

Department of Physical Medicine Rehabilitation and the Radioisotope Unit, VA Hospital, Cleveland.
Department of Medicine, Western Reserve University, Cleveland.

tended from the beginning of injection until the onset of rise in count at the groin.

Initial control readings were obtained with the subject in the horizontal recumbent position. When several different tests were performed on the same patient one or more additional control readings were made again. Methods of applying pressure and of altering posture are described in this study.

The temperature of the room in which tests were performed varied between 21.0 C. and 28.5 C. from day to day, but did not change more than 0.5 C. during the course of several tests on a given subject.

RESULTS

Effect of Popliteal Pressure

After an initial control reading was obtained in the recumbent position, a folded cloth pad 4 x 4 inches square and 2 inches in thickness was placed under the popliteal area so as to bear the weight of the leg in this region. Pressure was thereby exerted on the underlying popliteal and short saphenous veins. Results are tabulated in table 1. The average control time for the twenty-four patients was twenty-eight seconds with a range of eight to ninety seconds. The mean for the group during application of pressure was reduced to fourteen seconds and individual readings varied between three and fifty seconds. All subjects save two, experienced reduced time with the pressure pad in place.

Table 1: Effect of Popliteal Pressure

Arterial or Venous Disease	Age	Time in Seconds Control	Popliteal Pressure
None	61	8	4
None	66	90	50
None	31	23	6
None	60	14	4
None	55	15	3
Varicosities	40	42	8
None	56	3	4
None	28	26	12
None	35	17	8
Arteriosclerosis	55	40	15
None	30	20	14
None	35	35	9
None	44	51	8
None	25	17	12
None	32	15	7
None	32	19	10
Severe arteriosclerosis	76	19	16
None	37	9	4
None	62	14	6
Varicosities	55	43	15
None	66	20	49
Arteriosclerosis	61	68	23
None	61	23	28
None	30	23	11
Mean:		28	14

Calf Pressure

In eleven patients pressure was applied under the calf by means of a pad four inches thick and approximately four inches wide. Venous channels affected by such pressure would include the short saphenous and possibly the posterior tibial veins. Table 2 indicates that the foot-to-groin time for the group was reduced to twenty-one seconds as compared with the mean control time of twenty-eight seconds. Results however were not as consistent as those with popliteal pressure. Two subjects showed prolongation.

Table 2: Effect of Calf Pressure

Arterial or Venous Disease	Age	Time in Seconds Control	Calf Pressure
None	60	14	4
None	55	15	15
Arteriosclerosis	55	40	25
None	30	20	17
None	32	23	8
None	30	23	15
Severe arteriosclerosis	76	19	17
None	66	20	56
Varicosities	55	43	19
Arteriosclerosis	61	68	23
None	61	23	28
Mean:		28	21

Variable Cuff Pressure

A blood pressure cuff was placed about the prominent portion of the calf and inflated to pressures varying from 0 to 100 mm. Hg. Almost invariably it was observed that as pressure was progressively increased, the circulation time at first, diminished to a minimum and then rose again to relatively high values (fig. 1).

Lowest values were produced by pressures of 10 to 20 mm. Hg. This degree of compression undoubtedly was sufficient to occlude the superficial venous system but not the deeper vessels. Greater degrees of compression would be expected to constrict all venous channels and also reduce arterial flow to some extent.

Knee Flexion

In twelve patients the knee was flexed to an angle of ninety degrees (table 3). It is evident from the recorded data that

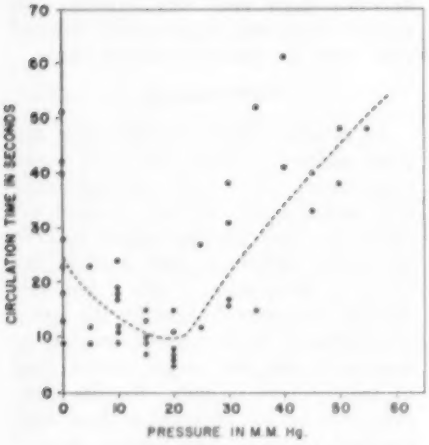


Fig. 1 — Effect of variable circumferential cuff pressure on circulation time.

Table 3: Effect of 90° Knee Flexion

Age	Time in Seconds Control	90° Flexion
66	22	20
35	17	24
22	7	11
43	11	13
28	41	N*
30	27	7
36	8	8
25	30	10
56	35	N*
44	26	8
32	18	5
61	8	8

None of these subjects showed manifest arterial or venous disease of the lower extremities

*N = No end point

this position produced no consistent decrease or increase of time.

Sitting and Standing

After an initial control time had been obtained the patient was carefully assisted to the sitting position with the legs extending over the side of the table and the feet resting lightly on a stool. A reading was obtained first in this position and then again after an erect posture had been assumed on the floor. In the latter position saline ceased to flow through the needle and considerable pressure was required to eject the tracer material from the syringe.

Of the ten patients tested in a sitting position, three showed a reduction in time, four, an increase and three, little or no change. When tested in a standing position, nine patients showed an increase and a reduction was evident in one (table 4).

Table 4: Effect of Sitting and Standing

Age	Time in Seconds Control	Sitting	Standing
33	22	29	N**
51	14	6	32
62	24	11	28
44	30	24	47
55	35	38	69
22	9	22	42
43	11	14	18
53	47	45	30
21	39	50	50
35[1]	21	29*	30

[1] This patient had varicosities. All others showed no manifest arterial or venous disease of the lower extremities.

* Leg horizontal
** N = No end point

Leg Elevation

During these tests the leg was elevated to ten, twenty or thirty degrees from the horizontal by means of an adjustable leg board. A total of 195 separate tests were performed on 94 subjects. In nineteen instances, no rise in activity was detectible at the groin up to three minutes after injection. These were considered as having no measurable end point. They are analyzed separately.

Figure 2 graphically portrays the effect of elevation in a series of patients with no demonstrable arterial disease.

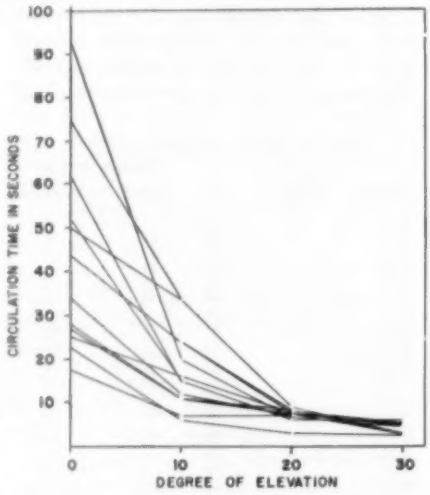


Fig. 2 — Effect of angular elevation on circulation time of twelve normal patients.

The twelve patients were tested at ten, twenty, and thirty degrees elevation in sequence. The results shown in figure 3 are a composite of the observations from

fifty-two patients who were tested at one or more positions at random. It is evident that elevation of the leg to ten degrees substantially reduces the circulation time. A further reduction is apparent at twenty degrees, and a slight additional decrease at thirty degrees.

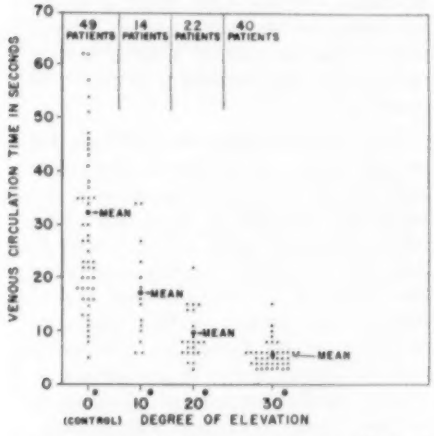


Fig. 3 — Composite results of the effect of angular elevation on unselected patients. The value of P for the difference of means between all successive groups is less than 0.01.

When the observations in figure 3 are studied in terms of individual patients, the effects of elevation may be summarized as follows: All patients, with one exception, showed a decreased time with all degrees of elevation. This one patient demonstrated a control time of twenty-five and twenty-seven seconds at ten degrees elevation. Reductions as small as two seconds or less were encountered in only four cases. One of these was from the group of fourteen tested at ten degrees elevation. The decline was from twenty seconds control to eighteen seconds elevated. The other three showed reductions at thirty degrees elevation of one second from a control of five seconds; two seconds from a control of thirteen seconds, and two seconds from a control of twelve seconds.

Of the nineteen patients with no detectible endpoint while the leg was horizontal, two out of three showed a measurable reading at ten degrees elevation and all who were tested at twenty and thirty degrees exhibited a good end-point. The data are summarized in table 5.

Table 5: Effect of Elevation
Patients Exhibiting No End-Point in Control

Age	Time in Seconds Degree of Elevation 10°	20°	30°
31			3
27			12
44			15
55*			22
61*			7
62			3
29			3
58			11
37			7
27			4
41			7
28			3
58	21	16	12
26	18	4	
59		11	
59		8	
44		3	
61		3	
64*	N**	24	22

* These patients had arteriosclerosis. All others showed no manifest arterial or venous disease of the lower extremities.

** No end point.

The reduced scatter in observed values at thirty degrees of elevation suggested the possibility that at such an angle, with no pooling of blood in the veins, venous circulation time might be reflective of the rate of arterial circulation. In order to test this hypothesis, twenty-two patients were carefully evaluated clinically for the presence or absence of arterial disease.* Of these, six were considered to be entirely normal and seven to be suffering from moderately severe to severe arteriosclerosis obliterans.

Among the six normal subjects, the venous circulation time at thirty degrees elevation ranged from two to seven seconds. In four patients diagnosed as suffering from severe arteriosclerosis, the time varied between eight and eleven seconds. Of those, three characterized as moderately severe, the times were four, six and sixteen seconds, respectively. The two patients with low values each had previously received a sympathectomy on the involved side. The one with a time of sixteen seconds was in cardiac decompensation.

Discussion

Blood originating from the dorsal venous arch of the foot may traverse several possible routes in its transit to the common femoral vein. The long and short saphenous veins are the prin-

cipal superficial pathways. The anterior and posterior tibial veins which empty into the popliteal and femoral vein comprise the deep system. When circulation time is measured from the dorsal vein of the foot to the femoral vein at the groin both the deep and superficial channels would be expected to share in the transport of blood.

Mean circulation time of the blood within the entire venous system lying between the exit of the capillary bed of the foot and the femoral vein could be obtained with precision only if it were possible to record separate time-concentration curves over the two points in sequence. This might be possible if injection were made rapidly into the femoral artery and with counters placed over the foot and groin. The present technic allows only an estimate of shortest time, i.e., the time of the fast moving particles. It must also be pointed out that material injected into a small vein of the foot may sometimes remain isolated near the spot where it is introduced, even though blood is moving rapidly through parallel channels of the complex venous network. This is undoubtedly the reason for the failure to obtain a reading at the groin in a certain proportion of patients. In the majority of instances, a sharp rise in count can be obtained. Here it is obvious that active flow at the point of injection has carried the test substance into the main channels of drainage of the foot. When this occurs it is likely that the time required to reach the groin at least represents an approximation of the velocity of blood flow in the several main channels leading to the common femoral vein.

The decreased circulation time which was seen to follow compression of the deep system by popliteal pressure, and of the superficial system by a pressure of 10 to 20 mm. Hg. applied through a constricting cuff would be anticipated on theoretical grounds. Velocity of flow depends both on volume flow per unit time and the volume capacity of the system. The classical expression of Stewart is: $t=q/F$, where t is time, q the volume of the system, and F the rate of flow in volume per unit time. If the volume (q) of the actively flowing venous blood in the leg is reduced by blocking out some of the participating venous channels, t will be reduced. Total volume likewise would be substantially decreased by drainage of the venous system during elevation. On the other hand it would be increased during standing. Hence there is an increase of velocity during elevation of the leg and a decrease on standing.

The value of thirty-five seconds for average foot-to-groin time in the entire group of subjects when measured in the horizontal position is surprisingly long when compared with the arm-to-heart time of six to seven seconds for venous flow obtained by Blumgart and Weiss.[8] Because the present technic measures the time via the fastest route within a complex system, it may be presumed that certain parallel streams of blood move at even slower velocities. The susceptibility of the lower extremity to venous thrombosis is therefore not surprising. The well-marked influence of localized pressure and of posture may also have a significant bearing on the problems of phlebothrombosis. The distinct decrease in circulation time which was almost always obtained following compression of either deep or superficial vessels suggests that, in spite of various anastamotic channels, a considerable component of the venous bed is rendered stagnant as a result of being bypassed. This finding emphasizes the inadvisability of placing pillows under the knee or calf of bedridden patients. The fact that tracer material sometimes fails to leave the site of injection while the leg is horizontal and with no compression applied anywhere, indicates that it is not rare for flow to be at a standstill in peripheral portions of the venous network under such basal conditions.

The remarkable speed-up in velocity of flow which attends elevation of the leg and the failure to observe stasis at the site of injection in such circumstances suggests that venous thrombosis would be materially retarded by this simple postural alteration. The effect of

twenty degrees elevation on velocity of flow is much more striking than the change which follows a shift from the standing position to the horizontal.

The tendency for venous time to be prolonged with thirty degrees elevation of the leg in the presence of severe arteriosclerosis suggests that such a procedure may have value in the evaluation of arterial incompetency. The group of patients studied, however, is too small to permit a valid statistical evaluation.

Summary and Conclusions

Venous circulation time from the foot to groin was found to be shortened by application of pressure to the popliteal area. Pressure to the posterior calf muscles was less consistent in shortening the time.

A constricting pressure of 10 to 20 mm. Hg. applied to the calf by means of a blood pressure cuff reduced the circulation time. This effect was reversed by raising the pressure to higher values.

Flexion of the knee and assumption of a sitting posture produced no consistent effect. The time was prolonged in the upright standing position. Elevation of the leg with the patient recumbent resulted in a marked decrease in time.

In a small series of patients with arteriosclerosis obliterans tested with the leg elevated to thirty degrees, there was a tendency for the time of venous flow to be prolonged.

References

1. Zankel, H. T.; Clark, R. E., and Shipley, R. A.: Effect of Physical Modalities Upon Saphenous Circulation Time Using a Radioactive Tracer. Arch. Phys. Med. & Rehab., 34:360, 1953.
2. Shipley, R. A., and Clark, R. E.: Performance of a Sodium Iodide Scintillation Counter in Measurement of I^{131} Uptake by the Thyroid. J. Lab. & Clin. Med. 41:179, 1953.
3. Blumgart, H. L., and Weiss, S.: Studies on the Velocity of Blood Flow. VII: The Pulmonary Circulation Time in Normal Resting Individuals. J. Clin. Invest. 4:399, 1927.

*We are indebted to Dr. V. L. Tichy for performing the special examinations in conjunction with this study.

For reprints, write Dr. Zankel, Chief, Physical Medicine Rehabilitation Service, VA Hospital, 7300 York Rd., Cleveland 30, Ohio.

CHICAGO SOCIETY TO MEET

The Chicago Society of Physical Medicine and Rehabilitation will hold its monthly meeting in Milwaukee on Friday, May 20, 1955. Dr. George A. Helmuth, Director, Cardiovascular Section of the Marquette University School of Medicine, will discuss "Rehabilitation of the Cardiac Patient" on the scientific program which is scheduled at 3:00 p.m., VA Hospital, Wood, Wis. At 5:00 p.m., the group will test Pabst Products; dinner will be served at Forest-Keller restaurant. For complete information and reservations for this meeting, write Gusta Davidsohn, M.D., Mt. Sinai Hospital, California at 15th Pl., Chicago.

A Double Purpose Whirlpool

J. L. Rudd, M.D.
Brockton, Mass.

A combination arm and leg whirlpool bath which in reality, serves a dual purpose is described (fig. 1).

The motor-driven turbine, connected with the whirlpool, is placed into the smaller of the two tanks when whirlpool treatment is prescribed for the forearm.

If leg or body immersion is needed, the smaller tank can be easily lifted out of the larger container by elevating the turbine to permit such removal. After this tank is removed, the turbine is lowered into the larger tank for its whirlpool action and hydromassage effect.

The smaller tank has attached to it, metal protruberances by which it is supported on the upper part of the outside tank. The small whirlpool fits snugly into the larger tank. The measurements of the combination arm and leg whirlpool are:

Large Tank	Small Tank
28″ long	24″ long
16″ wide	14″ wide
28″ deep	13″ deep

The advantages of this combination arm and leg whirlpool bath are savings in space; the difference in the cost of purchasing two complete and separate whirlpool baths plus a "skeleton tank"; use of water; use of heat, and length of time required to fill a large tank when only a smaller one is needed. It is believed this is one of the few, if not the only combination whirlpool in use.

Fig. 1—Combination arm and leg whirlpool bath.

Chief, Physical Medicine and Rehabilitation Service, VA Hospital, Brockton, Mass.

For reprints, write Dr. Rudd, 371 Commonwealth Ave., Boston 15, Mass.

Any member of the American Congress of Physical Medicine and Rehabilitation wishing to submit the name of an individual for consideration by the Gold Key Award Committee, may do so by sending such information to the Congress office no later than May 1, 1955.

Performance and Metabolic Alterations During Betaine Glycocyamine Feeding in Myasthenia Gravis

Harvey E. Billig, Jr., M.D.
and
Laurence E. Morehouse, Ph.D.
Los Angeles

Feeding of creatine for the purpose of providing larger than normal amounts in conditions of muscular weakness and degeneration is ineffective because it leaves the body without becoming fixed as phosphocreatine, which is the substance that yields the energy for physiological and metabolic work. Creatine in its useful form can be provided by feeding two of its precursors, betaine and glycocyamine. Betaine interacts in the body with homocysteine and converts it to methionine. Methionine then mythylates glycocyamine in the liver and creatine is formed which is then transported to the muscle where it interacts with adenosinetriphosphate to produce the desired phosphocreatine. One of the reasons this form of creatine supply is more satisfactory is that it is made available slowly and continuously over a long period of time, and hence not so much is lost by excretion.

The biochemical basis of betaine glycocyamine therapy has been adequately reviewed by Borsook and Borsook.[1] The successful use of betaine glycocyamine feeding in acute anterior poliomyelitis has been reported by Borsook, Billig and Golseth.[2] In the latter report, further biochemic rationale is presented and an advisable dosage schedule is suggested.

Betaine glycocyamine feeding is observed to be effective in anterior poliomyelitis and in other diseases characterized by defective creatine metabolism.

This report describes an objective assay of daily changes in muscular strength and metabolic alterations following withdrawal and restoration of betaine glycocyamine feeding in a myasthenia gravis patient.

From the Billig Clinic and the University of Southern California, Los Angeles.

Experimental Design and Methods

The patient, a woman 65 years old, weighing 116 pounds and 4 feet 9 inches in height, had been suffering from myasthenia gravis for at least seven years. Before receiving betaine glycocyamine therapy, her muscular function had deteriorated to the degree that she was unable to speak in an audible voice. She was too weak to maintain balance in a standing position and incapable of preparing meals and performing other light household tasks. After an eight week therapeutic regime consisting of high protein, minimum carbohydrate standardized diet,[3] 1/120 grain colchicine three times daily, 18 grams of betaine, and 3 grams of glycocyamine daily, in three individual doses, the patient regained her voice, her balance and her ability to perform household tasks. She agreed to discontinue the betaine glycocyamine feeding for the purpose of the experiment and a schedule of measurements was established.

The therapeutic regime was continued unchanged except that betaine glycocyamine feeding was withdrawn for a period of eight days and then restored. Commencing two days before withdrawal, daily measures of muscular strength and voice were recorded and complete daily urine creatinine and creatine determinations were made for twenty-five days. Daily records of height and weight, and pulse rate and blood pressure were made, but none of these varied regularly during the experiment.

Muscular strength of twelve different muscle groups were isometrically tested using a spring dynamometer and suitable fixed cable attachments similar to those described by Clark.[4] Excepting neck extension, strength tests were uni-

lateral employing the patient's dominant right extremities. The strength of each muscle group was tested repeatedly until no further gain could be achieved, and in each set of repetitions the maximum exertion was followed by two additional attempts to exceed it. The patient was encouraged to exert full effort during each trial. Pulls against the dynamometer were exerted in a slow and steady manner with the patient's body stabilized to eliminate extraneous movements. The joints of the flexor and extensor muscles under observation were placed in a position so that they would be flexed to a ninety degree angle at the maximum dynamometer reading. In all observations the segment in motion was in a position parallel with its gravital line. The following strength measures were obtained in the order given: 1. Hand grip; 2. leg extension; 3. forearm supination; 4. forearm pronation; 5. neck extension; 6. knee extension; 7. hip flexion; 8. elbow extension; 9. plantar flexion; 10. hip abduction; 11. knee flexion, and 12. shoulder abduction.

The voice was registered on a tape recorder with care taken to keep the amplification, microphone-to-mouth distance and other conditions uniform. The patient recited a set poem each morning following the strength tests.

Results

Dynamometric measurements shown in table 1 reveal a uniform deterioration of strength in all muscle groups during the eight day withdrawal of betaine glycocyamine. Following restoration of betaine glycocyamine, muscular strength was gradually and uniformly improved and returned to pre-withdrawal levels in about two weeks.

Urine creatinine and creatine excretions in twenty-four hour periods during withdrawal and restoration of betaine

Table 1: Muscular Strength (Pounds)

	DATE	Hand Grip	Leg Extension	Forearm Supination	Forearm Pronation	Neck Extension	Knee Extension	Hip Flexion	Elbow Extension	Plantar Flexion	Hip Abduction	Knee Flexion	Shoulder Abduction
ON B & G	Oct. 20	35 3/4	30	7 3/4	9 1/2	20	40	35	12	22	12	10	13
	21	37	37	9	6	26	44	28	12	20	30	10	14
WITHDRAWAL OF B & G	22	36	30	7 1/2	7	22	38	19	12	16	18	8	14
	23	33	27 1/2	7 1/2	7 1/2	19	42	18	10	18	9	8	7
	24	33	30	6 1/2	6 1/2	18	41	16	11	13	9	7	8
	25	33	27	5 1/4	6 1/2	16	38	18	10	20	10	10	11
	26	35	29	6 1/2	7	22	40	14	12	19	22	8	7
	27	35	20	6 3/4	7	16	38	13	12	17	18	6 3/4	13
	28	33	15	4 3/4	6 1/2	14	32	16	10	12	20	6 1/2	11
	29	35	20	5 1/2	6	11	36	17	10	14	19	6	8
RESTORATION OF B & G	30	35	25	6 3/4	6 3/4	15	40	15	11	12	16	7	11
	31	30	27	7	7 3/4	16	44	17	12	19	24	7 1/2	13
	Nov. 3	36	28	6 1/2	7 1/2	17	38	18	12	24	27	7 3/4	9
	6	35	25	7 1/2	7 3/4	23	41	22	13	22	22	7 3/4	15
	10	36	32	6 3/4	8 1/2	18	40	23	13	26	35	8	18
	12	38 1/2	30	7 3/4	9 1/4	22	42	19	13	28	29	7 1/2	18

glycocyamine are shown in table 2. Concentrations of creatinine and creatine decreased following betaine glycocyamine withdrawal and recovered gradually, approaching pre-withdrawal levels two weeks after restoration. This uniform relationship between decline and recovery of strength and decline and recovery of creatine metabolism during alterations in betaine glycocyamine ingestion suggests that in this myasthenia gravis patient a defective creatine (Phosphocreatine, Adenosinetriphosphate) metabolism was corrected, at least in part, by replacement of substances essential to proper biochemical processes supporting muscular function.

The sudden and coincidental decline in strength, creatinine and creatine when betaine glycocyamine was withdrawn indicates that betaine glycocyamine feeding must be maintained in order to be continuously effective.

Reestablishment of previous strength and creatinine and creatine levels following restoration of betaine glycocyamine feeding was much less rapid than the decline following withdrawal. The major decline following withdrawal occurred in four days, whereas two weeks were required for recovery. Evidently, in the absence of betaine glycocyamine therapy, catabolism overbalanced anabolism in this patient.

Within one week following withdrawal of betaine glycocyamine, the patient had physically retrogressed so that she had great difficulty in speaking,

Table 2: Urine Creatinine and Creatine

	Date	(ml.) Total Volume	(grams / 24 hours) Preformed Creatinine	Total Creatinine	Creatine as Creatinine	Creatine
ON B & G	Oct. 20	0.917	0.952	2.582	1.630	1.891
	21	1.145	0.9114	2.634	1.723	1.999
WITHDRAWAL OF B & G	22	0.704	1.019	1.633	0.614	0.724
	23	0.811	0.921	1.387	0.456	0.539
	24	0.879	0.812	1.202	0.392	0.452
	25	0.747	0.708	0.971	0.163	0.189
	26	0.979	0.729	1.031	0.300	0.348
	27	0.738	0.709	1.039	0.330	0.383
	28	0.652	0.7198	0.9415	0.222	0.258
	29	0.625	0.693	0.915	0.322	0.374
RESTORATION OF B & G	30	0.803	0.867	1.673	0.807	0.936
	31	1.318	1.397	2.383	0.986	1.044
	Nov. 3	0.561	0.788	1.726	0.936	1.086
	6	1.405	0.7050	1.8771	1.1721	1.3596
	10	1.450	0.8980	1.8903	0.9918	1.1505

maintaining balance and performing light household duties. At the end of the second week following restoration of betaine glycocyamine the patient's voice was again clear and strong, her balance and strength had recovered and her ability to perform housekeeping tasks had returned to the pre-experimental level.

Summary

A uniform decline and recovery of muscular strength and urine creatinine and creatine following the withdrawal and restoration of betaine glycocyamine feeding in a myasthenia gravis patient undergoing otherwise standardized therapy is described.

References

1. Borsook, H., and Borsook, M. E.: Biochemical Basis of Betaine Glycocyamine Therapy. Ann. West. Med. & Surg. 5:825 (Oct.) 1951.
2. Borsook, M. E.; Billig, H. E., and Golseth, J. G.: Betaine and Glycocyamine in the Treatment of Disability Resulting from Acute Anterior Poliomyelitis. Ann. West. Med. & Surg. 6:423 (July) 1952.
3. Billig, H. E.: The Specialist Looks at Everyday Medical Care in Industry: Orthopedics. J.A.M.A. 146:1179 (July 28) 1951.
4. Clark, H. H.; Bailey, T. L., and Shaw, C. T.: New Objective Strength Tests of Muscle Groups by Cable-Tension Methods. Res. Quart. 23:136 (May) 1952.

For reprints, write to Dr. Billig, 139 S. Alvarado St., Los Angeles 57, Calif.

The authors express gratitude to L. F. Pierce, Ph.D., for performing all biochemical analyses; to Herbert Daykin and Joseph Reeves for their assistance in the administration of the performance tests.

Myositis Ossificans Complicating Poliomyelitis

J. P. Stoikovic, M.D.
M. Bonfiglio, M.D.
and
William D. Paul, M.D.
Iowa City

Introduction

As the number of cases of poliomyelitis increases and the mortality rate decreases, we have an opportunity of observing the course of the disease and its complications. At present, more patients are living who remain confined in respirators or who have complete paralysis. The commonest complication among individuals with respiratory paralysis is an atelectasis and/or pulmonary infections. Patients who are confined to bed and unable to move are known to have changes in calcium metabolism.[1,2] At first, more calcium is excreted than retained by the body. Later the calcium metabolism becomes normal. During the early phase of the negative calcium balance, calcium is deposited in the blood vessels, muscles, kidneys and bladder, as well as other tissues, since the kidneys cannot excrete all the calcium in the blood. Stones may be formed in areas vulnerable to infection, such as the kidneys, renal pelves and bladder. Most of the patients, we have observed, who are confined to respirators or rocking beds have developed renal, ureteral or bladder stones. Knowing that heterotopic ossification can occur in muscles of paraplegics, we thought the infrequency of this complication in our cases of poliomyelitis to be unusual.

Heterotopic ossification has long been recognized as a complication of posttraumatic paraplegia and quadriplegia.[1-4] It has also been observed in patients with other diseases of the central nervous system, such as syringomyelia, spastic paraplegia, tabes dorsalis and luetic meningo-myelitis.[5-9] It was not until 1927 that Drehman first reported this complication in a patient with polio-

Read at the Thirty-second Annual Session of the American Congress of Physical Medicine and Rehabilitation, Washington, D.C., September 11, 1954.

From Department of Medicine (Dr. Stoikovic), Orthopedics (Dr. Bonfiglio), and Physical Medicine (Dr. Paul), College of Medicine, State University of Iowa, Iowa City.

myelitis.[10] Since then, a few additional cases were reported by Babonneix and Miget, Hess, and Costello and Brown.[11-13] Freiburg reported two cases from the University of Iowa Hospital; both are discussed in detail in this paper.[14]

During the years 1949 through 1953 we have treated 1980 cases of acute poliomyelitis. Although we were cognizant of the fact that myositis ossificans could develop during the course of poliomyelitis, only six instances were noted during the past five years. This is more striking when one realizes that the patients were hospitalized for long periods of time and that many are still being observed. The ages ranged from twelve to forty years. Ossification was first noted six to fifteen weeks after the onset of the disease. Extreme paralysis involving the trunk, legs and arms was present in these patients. In three, thrombophlebitis preceded the myositis ossificans. Biopsies or resection of the mass were performed in four of the cases. One patient died of pulmonary complications and the myositis ossificans, noted previously, was proved at post-mortem examination.

Case One

R. Z., age 22, male, had the onset of poliomyelitis on August 3, 1949. He exhibited urinary and fecal incontinence, paralysis of both lower extremities, trunk, and partial paralysis of the right upper extremity. He became irrational and cyanotic and required a respirator for three weeks. Twelve weeks after the onset there was pain and swelling of the left leg and thigh with a positive Homan's sign. A diagnosis of thrombophlebitis of the left lower extremity was made. For a period of several weeks, residual swelling was observed about the inguinal region and buttocks. Limitation of motion of the left hip occurred about fifteen weeks after the onset of the disease. Simultaneously urinary tract infection and bladder calculi developed, for which the patient was treated by the urologist. Later, a mass in the left hip region was noted. Roentgenograms taken on August 11, 1950, one year after the onset of the disease, showed mature ossification in the region of the anterior superior iliac spine over the left hip joint. The specimen removed at operation measured 3 x 5 x 3 cm. The section showed ossification in the connective tissue with the usual intertrabecular vascularization. Removal of the mass resulted in continuing improvement in motion.

Case Two

J. K., age 23, male, was admitted to the hospital on September 1, 1949, four days following onset of the illness. Physical examination revealed marked stiffness of the neck and lumbo-dorsal muscles; pronounced weakness of the right deltoid muscle as well as flexors and extensors of right forearm; paralysis of abdominal rectus muscles, and generalized weakness of both thighs and the extensors of the left leg. Slight deviation of the uvula to the left and diplopia due to convergence of eyeballs, was present. The following day a widespread paralysis of right upper and both lower extremities developed as well as weakness of other muscle groups. After a week in the hospital, physical therapy consisting of stretching exercises was started. After improvement, passive stretching was gradually changed to active exercises. Approximately four months from the onset of the disease a hard mass was palpable on the region of the left groin which limited flexion of the left thigh and caused moderate pain on motion. Roentgenograms showed a diffuse area of increased density surrounding the left hip joint and extending parallel to the femoral shaft, anteriorly to the subtrochanteric area. Osteoporosis of visualized bones was present.

At the time of discharge, five and one-half months after onset of the disease, the patient still had marked weakness of the right upper, and moderate weakness of both lower extremities, but was able to move around with the aid of crutches. He was unable to manage stair climbing. The following year he returned to school.

Case Three

M. A., age 12, female, was admitted February 19, 1950, to the University Hospital, five days after the onset of headache, fatigue, malaise, fever, and weakness of legs.

At the time of admission she had weakness of the left upper extremity, trunk and both lower extremities. Within a few days the paralysis became generalized except for the muscles of respiration. Stiffness and pain was a prominent feature and persisted for at least four months. A low grade fever was present until the seventh week of the illness, when the temperature rose to 101 F. At this time swelling developed in the right leg and foot. The fever subsided after a few days. Because of the tightness and pain, physical therapy was again prescribed. During the fourteenth week of the disease, pain and swelling appeared in the upper right thigh along the antero-medial aspect. There was an increase in local heat and redness of the skin over this area. A diagnosis of acute thrombophlebitis was made because of the elevated temperature (103 F.), and the presence of a positive Homan's sign. Roentgenograms of the right hip showed extensive ossification in the adductor region while a lesser amount was seen in the left adductor area. Extensive para-articular ossification was present in the right shoulder and to a lesser degree in the left shoulder. Calcium was also noted in the left paravertebral muscles. The serum calcium was 10.6 mg. per cent; serum phosphorous 3.7 mg. per cent; alkaline phosphatase 29.4 Jenner-Kay units, and the urinary calcium excretion was increased. A biopsy of the mass in the right thigh showed ossification occurring in fibrous tissue, a small amount of cartilage, and a small area of hemorrhage. Microscopic sections from the region adjacent to the muscle fibers showed more mature bony trabeculae with loose connective tissue in the marrow spaces. Physical therapy was discontinued. On bed rest alone, the pain and swelling gradually subsided. Two months later, roentgenograms showed diminution in the ossification at all sites. The serum calcium, phosphorus and phosphatase returned to normal levels. At this time, both the right hip and left shoulder were irradiated with 600 roentgen units. A dose of 200 roentgen units was given to the other ossified areas. This was done as a palliative measure for relief of persistent pain. The patient was allowed to go home and did not return for follow-up study.

Case Four

T. B., age 38, female, was admitted August 29, 1952, seven days after the onset of her illness. Shortly after admission, she developed generalized paralysis and had to be placed in a tank respirator. She remained in the respirator for a period of twelve weeks, during which time hot packs were applied intermittently and mild passive exercises were given. Two weeks after discontinuance of the respiratory aid she complained of soreness in the upper part of the left thigh. A bony-hard, tender mass was palpable anterially and medially to the greater trochanter. Roentgenogram showed areas of increased amorphous density in the soft tissues around the intertrochanteric and femoral neck regions. All visualized bones were osteoporotic. A vesical calculus, the size of a pea, was also seen (fig. 1-A). The patient was given a total dose of 1800 roentgen units to the involved area. One month later the roentgenogram showed an increase of the amount of ossification about the hip joint and upper medial aspect of the femur, while the vesical calculus also increased in size.

A biopsy of the mass was performed ten weeks after its discovery. Microscopic sections showed dermis, adipose and areolar tissue, with extravasated blood, and a zone composed of trabeculated bone and fibrous tissue (fig. 1-B). The fibrous tissue revealed proliferation and in certain areas a differentiation into osteoblasts. The bone was of secondary type without evidence of primary bone or osteoid tissue. Osteoblasts as well as osteoclasts were seen in apposition to this bone. Active resorption of bone by osteoclasts was a con-

Fig. 1A—Roentgenogram (case 4) of the left hip region shows deposits of amorphous bone in the soft tissues around the intertrochanteric and femoral neck areas, and a vesical calculus.

spicuous feature. The intertrabecular fibrous tissue was infiltrated by chronic inflammatory cells in a few places and old blood pigment was seen. The histological appearance was consistent with a relatively mature myositis ossificans. Relief from pain was obtained by roentgen therapy, and the range of passive movements increased to about sixty per cent of normal.

Case Five

M. M., age 22, male, was admitted to the University Hospital on September 12, 1952, in the preparalytic stage of the disease. The day prior to admission he fell and injured his hips. On the second day, the patient developed paralysis of both lower extremities, abdominal, lumbo-dorsal and respiratory muscles. He required the aid of a respirator. For a period of eleven weeks he remained in a tank respirator. Application of hot packs and passive movements of lower extremities was started two weeks after admission.

Six weeks after admission, he complained of soreness and tenderness of the anterior portion of the right upper thigh. Five days later moderate swelling of this area was noted. Within the next two weeks these symptoms increased in severity and the entire extremity became swollen. A diagnosis of thrombophlebitis was made, although leukocytosis was absent. After the swelling subsided, a stony-hard mass was palpated around

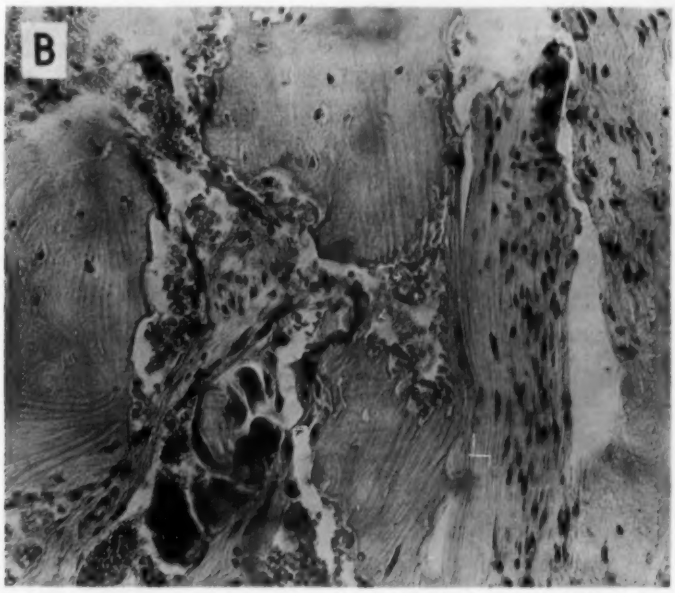


Fig. 1B — Photomicrogram (case 4) showing trabeculated secondary bone and fibrous tissue proliferation and some extravasated blood. Absorption of the secondary bone is seen.

the upper one-third of the right femur. A roentgenogram demonstrated a large area of increased density in the soft tissues surrounding the proximal third of the shaft of the femur, extending into the capsular and pericapsular areas of the hip joint; the bone and joint details were normal (fig. 2). Roentgen therapy to the involved area gave relief of discomfort. The patient was then transferred to another hospital.

Fig. 2 — Roentgenogram (case 5) showing large fan-like bone deposits in the soft tissues surrounding the proximal third of the right femur and extending into the capsular and pericapsular areas of the hip joint.

Case Six

E. M., age 40, male, was admitted to the University Hospital, October 20, 1952, five days after becoming ill. It was necessary to place him in a tank respirator as soon as he reached the hospital. Hot packs and passive motion were not started during the first two weeks because he was critically ill. Passive exercises or mild stretching produced an increase of pain. Nine weeks after admission a thrombophlebitis developed in the left leg. Pain was present in the calf, a positive Homan's sign was elicited, the regional lymph nodes were enlarged and tender, and the entire extremity was swollen. Only a reduction of density of the visualized bones was seen in the roentgenogram. After the swelling subsided, physical therapy was started once again. Five weeks later it was noted that passive movements of the right elbow caused considerable pain and that the range of motion was decreasing. A hard mass, the size of a marble, was palpable on the medial aspect of the right elbow. The roentgenogram showed soft tissue ossification overlying the olecranon and the medial epicondyle of the humerus. The joint space appeared intact. One month later, a film of the right shoulder showed a large amount of bone within the soft tissues surrounding the shoulder joint (fig. 3-A). There was some atrophy of the visualized bones. The patient died eight and one-half months after the onset of poliomyelitis. At autopsy, an atelectasis of the entire right lung and the lower left lobe was found. A terminal bronchial pneumonia was present in the right lower lobe. The ossification about the elbow was much larger than appeared on the previous films. An area of ossification was also found in the region of the right shoulder. Microscopic examination of the mass, adjacent to the right shoulder, showed bone, cartilage and fibroblastic tissue (fig. 3-B). The bone was viable and basically of a primary type with osteoblastic activity. In several areas foci of osteoid, precartilaginous connective tissue, and hyaline type cartilage blended interceptibly with the new bone. In other areas, particularly in the center of the bony lesion, there were numerous blood-filled vascular spaces. In these areas active resorption of bone was seen. Adjacent to this were foci of degenerating and necrotic bone and typical calcification. Some osteoclastic resorption of bone was noted, but this was not a conspicuous feature.

Other sections from the mass showed changes similar to those described. In addition, secondary bone was seen. Here cement lines and Haversian systems were conspicuous. Newly formed primary bone and osteoid was in direct apposition to the secondary bone. In other areas foci of hemorrhage with organization of the blood were seen. The tissue adjacent to the bony lesion was com-

Fig. 3A — Roentgenogram (case 6) of the right shoulder shows a large amount of bone within the soft tissues surrounding the shoulder joint.

Fig. 3B — Photomicrogram (case 6) showing metaplasia of connective tissue into enchondral type of cartilage and primary bone. The intertrabecular marrow shows vascular connective tissue.

posed of dense, partially hyalinized, collagenous tissue and atrophic skeletal muscle. The histologic appearance was that of an injury and repair type of lesion, entirely consistent with myositis ossificans. No inflammatory reaction was noted.

Discussion

Several theories have been proposed to explain the pathogenesis of myositis ossificans. Pathologists usually ascribe the histological changes preceding ossification to trauma.[25-28] They also state that metaplasia of fibrous tissue into bone can occur, believing that all primitive connective tissue is capable of differentiation. Another theory is that osteoblasts are detached as a result of trauma and become implanted in the muscle where they form bone. The importance of local edema, and the consequent chemical changes in the tissue fluids, has also been emphasized.[27-28] Many conditions are necessary for the pathological changes to occur, and since these do not appear at the same time, only a relatively small number of patients develop myositis ossificans.

It is commonly accepted, at present, that injury is the major cause of myositis ossificans. The trauma may be a single severe injury or multiple, small, repeated ones, such as muscle stretching or carrying an extremity beyond its normal range of motion. The damaged area undergoes typical changes, including the cardinal signs of inflammation. This is followed by fibrous tissue proliferation, metaplastic bone and cartilage formation and finally maturation. These changes take place about thirty days from the injury. The changes occur in the connective tissue in between the damaged fibers of the striated muscle. Hematoma, if present, undergoes absorption. The fact that all the cases reported previously, as well as the six described in this study, had some form of trauma, whether from a fall or repeated minor injuries, would support the concept of trauma as the precipitating agent in myositis ossificans.

In this series of cases there was no evidence of disturbance of serum calcium and phosphorous. This may be accounted for by the fact that the determinations were done after the diagnosis was well established. The alkaline phosphatase was elevated in one patient during the early active stage. It has been demonstrated that phosphatase activity does occur in muscle and fibrous tissue and is the preossification stage of myositis ossificans.[13] In our patients, rest and roentgen irradiation relieved pain and prevented an increase in ossification. No specific therapy is available. The value of peripheral vascular dilatation and vascular congestion of local tissue by means of ganglionic blocking is doubtful. After the complete maturation of the ossified tissues, surgical removal of the heterotopic bone will reestablish at least partial return of motion to the affected joints.

Summary

Heterotopic ossification is a well-known complication of post-traumatic paraplegia, or quadriplegia, and of other central nervous diseases. Until recently this complication was not recognized as a sequel to poliomyelitis. As a result the proper diagnosis has been delayed or mistaken. Histories of six patients with myositis ossificans complicating poliomyelitis observed at the State University of Iowa Hospitals were presented. In each instance, the patient had had extensive paralysis involving trunk, both lower and upper extremities. The age of the patients ranged from twelve to forty years. The onset of ossification was noted six weeks to four months after the onset of poliomyelitis. In three of the patients a thrombophlebitis of the involved lower extremity preceded the development of myositis ossificans. All of the patients had marked muscle spasm and tenderness which was aggravated by muscle stretching. Roentgen therapy afforded relief of pain.

References

1. Miller, L. F., and O'Nell, C. J.: Myositis Ossificans In Paraplegics. J. Bone

For reprints, write Dr. William D. Paul, Children's Hospital, Iowa City.

& Joint Surg. **31A**:283 (April) 1949.
2. Ceillier, A.: Para-Ostéo-Arthropathies des Paraplégiques par lésion de la Moelle Epiniere et de la Quene de Cheval, Paris, Imprimerie Generale Lahure, 1920.
3. Dejerine, M.; Ceillier, A., et Dejerine, Y.: Para-Ostéo-Arthropathies des Paraplégiques par lesion médullaire. Rev. neurol. **26**:399 (May) 1919.
4. Kuettner, H.: Beitraege zur Chirurgie des Gehirns und Rueckenmarks. Berl. Klin. Wchnschr. **45**:584 (Mar. 23); 654 (Mar. 30) 1908.
5. Abramson, D. J., and Kamberg, S.: Spondylitis, Pathological Ossification, and Calcification Associated with Spinal-Cord Injury. J. Bone & Joint Surg. **31A**:275 (April) 1949.
6. Brailsford, J. F.: Changes in Bones, Joints and Soft Tissues Associated with Disease or Injury of the Central Nervous System. Brit. J. Radiol. **14**:320 (Oct.) 1941.
7. Frejka, B.: Heterotopic Ossification and Myositis Ossificans Progressive. J. Bone & Joint Surg. **11**:157 (Jan.) 1929.
8. Geldmacher, M.: Beitrag zu den parartikulaeren Verknoecherungen nach Querschnittslaesion des Rueckenmarks. Deutsche Ztschr. Chir. **191**:180 (June) 1925.
9. Hanke, H.: Ueber die Myositis Ossificans Circumscripta Neurotica der Paraplegikern nach Wuerbelbruechen. Deutsche Ztschr. Chir. **258**:217, 1943.
10. Drehmann, G.: Myositis Ossificans Circumscripta Neurotica im Verlaufe der Poliomyelitis Anterior Accuta. Abstr. Zentralbl. f. die g. Neurol. u. Psychiat. **48**:686, 1927-28.
11. Babonneix, L., and Miget, A.: Ostéo-Périostite chronique de l'humérus chez un enfant atteinde paralysie infantile de membre supérieur. Bull. Soc. Péd. Paris **30**:25 (Jan.) 1932.
12. Hess, W. E.: Myositis Ossificans Occurring in Poliomyelitis. A.M.A. Arch. Neurol. & Psychiat. **66**:606 (Nov.) 1951.
13. Costello, F. V., and Brown, A.: Myositis Ossificans Complicating Anterior Poliomyelitis. J. Bone & Joint Surg. **33B**:594 (Nov.) 1951.
14. Freiberg, J. A.: Para-Articular Calcification and Ossification Following Acute Anterior Poliomyelitis in an Adult. J. Bone & Joint Surg. **34A**:339 (April) 1952.
15. Anderson, W. A. D.: Pathology, ed. 2, St. Louis, C. V. Mosby Company, 1953.
16. Boyd, W.: Text-Book of Pathology, ed. 5, Philadelphia, Lea & Febiger, 1950.
17. Wells, H. G.: Chemical Pathology, ed. 5, Philadelphia, W. B. Saunders Company, 1925.
18. Weinmann, J. P., and Sicher, H.: Bone and Bones, St. Louis, C. V. Mosby Company, 1947.
19. Leriche, R., and Pollicard, A.: Les Problems de la Physiologie normale et pathologique de l'OS, Paris, Masson et Cie, 1926.
20. Deitrick, J. E.; Whedon, D., and Shorr, E.: Effects of Immobilization upon Various Metabolic and Physiologic Functions of Normal Men. Am. J. Med. 4:3 (Jan.) 1948.

IMPORTANT NOTICE: CHANGE OF EXAMINATION DATE

AMERICAN BOARD OF

PHYSICAL MEDICINE AND REHABILITATION

The next examinations for the American Board of Physical Medicine and Rehabilitation will be held in Philadelphia, June 10, 11 and 12, 1955.

The Arthritic Foot: A Method of Taking Weight-Bearing Impressions for the Making of Supports

Robert Muller, M.D.
New York City

Foot Disorders

The function of the foot is to carry the weight on standing and walking. Most foot disorders arise from insufficiency of the mechanical structure. The structure can be weakened by disease, trauma or congenital anomalies. The purpose of an arch support is to protect the weakened structure of the foot and to correct developed deformities.

In practice, deformities of the foot are divided into two groups: 1) Disorders of the longitudinal arch and, 2) of the metatarsal area. Figures 1 and 2 illustrate the principle of how supports influence the longitudinal arch.

Fig. 1 — By placing the support underneath the sustentaculum tali, the arch will be raised and the foot shortened.

Fig. 2 — By placing the support underneath the shafts of the metatarsals, the foot will be elongated and the arch is lowered.

For a pes planus or valgus the highest point of the support should be far back enough to be nearly underneath the medial malleolus. Several commercial orthopedic shoes are built on this principle.

Examinations and measurements which deal with the position and the relative weight-bearing with each metatarsal have been under the influence of the axioms: 1) "There is no metatarsal arch" and, 2) "In standing and walking all the metatarsal heads are on a horizontal level pressed against the ground." These statements have been repeated so often that sight has been lost of the well-known fact that under the metatarsals in every old shoe mountains and valleys are found which have been dug into the sole by the pressure of the metatarsal heads.

While there is no anterior arch, each human foot has a characteristic metatarsal position pattern. In standing and walking the metatarsals fight to maintain their natural level. The mountains and valleys in the old shoes are the result of this fight. On hard pavement the metatarsal heads are pressed into one plane; on soft ground they assume their natural pattern. Old shoes are comfortable because the depressions under the metatarsals simulate walking on soft ground. In walking, as the foot is rolled off, the pattern becomes more pronounced and with it the stress is more intensified. Standard arch supports try to force the metatarsal heads by pads or bars into the same horizontal level. We have tried to introduce a different principle in the supports which have been developed in the Edward Daniel Faulkner Arthritis Clinic at the Columbia Presbyterian Medical Center by allowing the metatarsal heads to retain their natural position levels.

Read at the Annual Meeting of the American Society of Physical Medicine and Rehabilitation, Washington, D.C., September 7, 1954.

From the Edward Daniels Faulkner Arthritis Clinic, Columbia Presbyterian Medical Center, New York City.

This study was supported in part by a grant from the Masonic Foundation for Medical Research and Human Welfare.

Method

To obtain impressions which will answer this purpose, the patient stands on one foot in a box filled to a level of three inches with #5 cup grease. Box and grease are covered with a wet piece of stockinet. Impressions in grease have been described by Adler.[1] With alternating movements, the patient slowly puts his weight on the toes and heel; in other words he rocks back and forth until the foot sinks about two inches deep into the grease. As the foot goes down into the soft mass each metatarsal reaches its own level depending on the weight it carries. No predetermined plane holds them in place. The resulting position is only limited by the extent to which the interconnecting structures may be stretched.

Care is taken that the foot does not slip in the grease. If the foot slips, the impression should be retaken after smoothing the grease and respreading the stockinet. The foot is removed from the impression box and the imprint examined.

A perfect impression shows no air blisters under the stockinet. The heel is well outlined. Plaster of Paris can then be poured. Thus a weight-bearing cast is obtained which expresses the natural functional shape of the foot. Another advantage of this technic lies in the fact that a direct positive cast comes out of the mold upon which, without any further transfer, the arch support can be worked.

In the not too severely deformed feet, supports made from these simple untouched casts with their natural metatarsal levels have given satisfactory relief. Experience, however, has shown that in the more tender and severely deformed feet of the arthritic, full satisfaction can only be obtained if some corrections are added. These changes are made either to correct existing deformities or for the purpose of relieving tender areas from excessive pressure. In all, about seven types of alterations should suffice to deal with the most usual deformities.

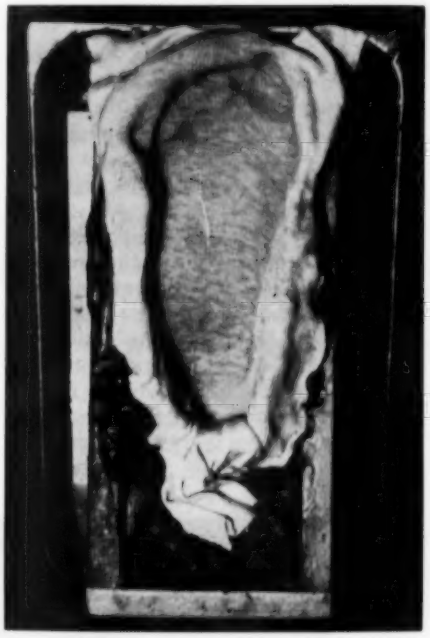


Fig. 3 — Weight-bearing impression grease.

Fig. 4 — Three casts of the same foot; reading from bottom up, weight-bearing on firm ground; dangling foot, and weight-bearing in grease.

I

As mentioned before, in severe flat feet correction must be obtained by raising the anterior part of the calcaneus. This is achieved in the following manner: After the impression in grease is obtained and before the plaster is poured, the heel on the skin of the patient is outlined with indelible pencil. Not to disturb the impression, the foot is carefully placed back into the grease. When it is taken out, the outline of the heel should be visible on the stockinet. With a round instrument e.g., handle of a screwdriver or the thumb, the outlined heel especially its medial half, is depressed from one-fourth to one-half inch into the grease. This elevates the sustentaculum tali in relation to the lowered heel.

II

Similarly in metatarsal problems, the heads of these metatarsals which carry too much weight causing calluses, rheumatic nodules, or just tenderness on pressure, are carefully outlined and this outline is transferred onto the stockinet. Only the heads should be so marked. The weight-bearing head, and not the shaft, should be depressed into the grease.

How deep the grease should be pushed down is a matter of experience. One should be guided by the condition of the skin. Thick painful callus or corns will need a deeper depression to achieve

Fig. 5 — Three casts of the same foot showing how the grease impression (right cast) is much more plastic than the others.

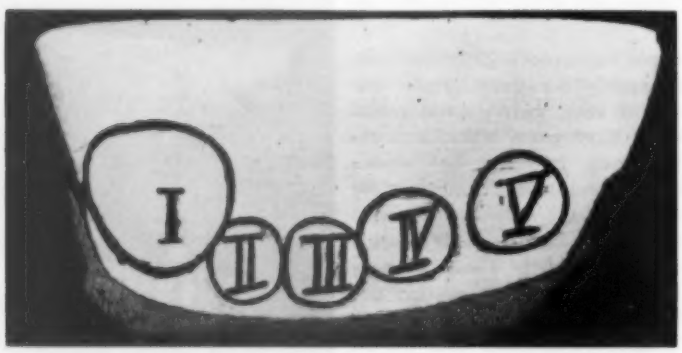


Fig. 6 — Vertical cut through a cast showing a typical metatarsal position pattern. The horizontal under surface of the support maintains the natural position.

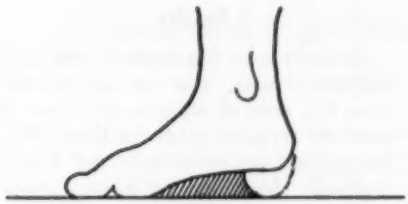


Fig. 7 — By depressing the grease under the heel, a support for the longitudinal arch (hatched lines) is obtained with the highest point underneath the sustentaculum tali.

relief than a superficial, not tender callus. It should be kept in mind that even the deep valleys in old worn out shoes are sufficient to prevent callus and corn formation. Sometimes, to correct severe imbalance, the second and third metatarsals must be allowed to sink one-half inch deeper than the fourth and fifth metatarsals. Each human foot has its own particular pattern, and only general rules can be given on how to make these corrections.

III

In flat feet: Apart from the previously mentioned elevations of the corpus calcanei, the other important correction is to permit the head of the first metatarsal to sink lower or at least as low as any other metatarsal. One of the characteristics of the cavus foot is that when it dangles, the first metatarsal hangs much lower than the fifth metatarsal. A correction of a flat foot in this direction is desirable, especially since the more vertical the position of the first metatarsal assists it to carry its correct share of weight. Strain from the second and third metatarsal is relieved. We have made it, therefore, a general rule in all flat feet to outline the head of the first metatarsal including the sesamoid bones, and depress the grease until this area is lower or as low as any other metatarsal.

Only in rare instances, when the head of the second metatarsal is extremely painful on weight-bearing, a thin platform — similar to supports used by Morton[9] — can be retained under metatarsal I for a week or two. As soon as the tenderness has sufficiently subsided the platform should be removed.

IV

In a cavus foot one must guard against making the longitudinal arch too high. The soft grease will not resist the inclination of the cavus foot to contract. It will tend to make a short impression with a high arch. Lowering the longitudinal arch can be accomplished by grinding down the finished arch support under the posterior half of the longitudinal arch. In this manner, since the anterior half of the support is left intact, a natural metatarsal bar results.

V

In metatarsal imbalance in a cavus foot, with a hallus valgus, or with arthritic changes in the first metatarsal joint, space must be provided by depressing the grease under this joint. In other cases relief is obtained by exaggerating the natural pattern of the metatarsals according to the pain and tenderness on weight-bearing. In other words, we depress the over-burdened metatarsal until the patient feels that all excessive weight-bearing is relieved. Podiatrists have always used balance therapy, i.e., relieving pressure under one metatarsal by raising the two neighboring heads. Our method goes beyond this. We are trying to reestablish the normal weight-bearing pattern.

VI

It is not advisable to retain a crest between the metatarsal and the toes. This crest is used in Murray shoes and most Levy moulds. We have found it to be of very little or no value. With the depression of the metatarsal levels the crest becomes disturbed, and its retention leads to endless complaints. Distal of the metatarsal impressions, our supports consist simply of a flat piece of leather. Even this can be cut off if the toes are crowded.

VII

The attachment of the m. tibialis anterior on the o. cuneiforme 1 and o. metatarsal 1 is often sensitive to pressure. Frequently arthritic changes are found in the joint between these bones.

This area is then not able to carry weight. Arch supports which disregard this possibility can cause discomfort. Before taking an impression, every foot should be tested for tenderness of the m. tibialis anterior attachment. If pain on pressure is found this area is carefully outlined, and after transferring it onto the stockinet, the grease is slightly depressed. With this change even high supports can be worn without discomfort.

After these corrections have been carried out and checked, the impression is ready for casting. When the cast is taken from the grease it may look surprisingly lumpy, but no further changes are made once the cast is poured. The dried cast is given to any arch support manufacturer who knows how to make a Levy mould. Levy moulds are made from sawdust and latex. The mixture is smeared over the cast so that the entire sole is covered and then baked in an oven for several days. The dried mould is peeled off, covered on top with leather, and the bottom ground down to fit the patient's shoe. When the finished support is fitted on a patient a small shoemaker's emery wheel should be available since small adjustments—such as grinding down excessive height—are often necessary. When the patient has worn the supports for a week they are checked. All the spots which show undesirable weight-bearing, recognizable by the discoloration of the leather, are further thinned down. To relieve particularly tender spots, even the top leather may have to be cut. A second and final check is usually made after a month has elapsed.

Results

Anybody who has worked with arch supports knows, that as an average, forty per cent of all patients refuse to wear the supports made for them. With the method my co-workers and I have gradually developed we have a maximum of one or two per cent rejections. We have completely discarded metal supports for arthritic patients and use only the method described.

After several weeks of wearing, tenderness and calluses gradually diminish. The painful cysts and swelling subside, and even many rheumatoid arthritic patients can walk or drive a car for a long distance.

Summary

Standard arch supports try to force the metatarsal heads by pads and bars into the same level. The principle of taking weight-bearing casts, which allows each metatarsal to seek its own level depending on the weight it carries, results in a new type of arch support. These supports, especially with the addition of the outlined corrections, relieve pain quicker and have definite corrective value.

For reprints, write Dr. Muller, 1111 Park Ave., New York City.

References

1. Adler, H. I.: Foot Man Makes Good Impressions. Esso Oilways, May 1948, p. 20.
2. Morton, Dudley J.: Human Locomotion and Body Form; A Study of Gravitation and Man, Baltimore, The Williams & Wilkins Company, 1952.

SECTIONAL MEETING SCHEDULED—

The Midwestern Section of the American Congress of Physical Medicine and Rehabilitation will meet on Friday, May 6, 1955 at the Mayo Memorial Auditorium (Mayo Memorial Building), University of Minnesota, Minneapolis. All physicians are cordially invited to attend this session. For further information, write to G. K. Stillwell, M.D., 200 First St. S.W., Rochester, Minn., or David Paul, M.D., 515 Ronalds St., Iowa City.

Functional Significance of Spinal Cord Lesion Level

Charles Long II, M.D.
and
Edith Buchwald Lawton, M.A., A.R.P.T.
New York City

Introduction

It is the purpose of this presentation to discuss the correlation existing between the level of spinal cord lesion and the eventual functional potential of the patient. In the absence of medical complications, the most important factor in this relationship is the amount of muscle power remaining to the individual. This power is determined by the levels of innervation of the critical muscle groups. Since these levels are fairly well documented,[1] it should be possible to estimate the functional potential of a given patient if the level of the lesion is known. Such an estimation of functional potential has value to all members of the rehabilitation team. It serves at the outset to delineate a possible goal for the patient, and later as a yardstick to the success of therapy.

Although this goal may be carefully delineated on the basis of muscle distribution, there are many factors which can prevent the patient from reaching it. The most important limiting factors are spasm, decubiti, insufficient motivation, deformity, urinary infection, stones and incontinence. Any one or combination of these problems may be present. It cannot be emphasized too strongly that the patient will be able to utilize fully his remaining muscle power only if these complications can be minimized or resolved.

For purposes of discussion seven critical levels of spinal cord severance are described. Beginning with the C-5 segment, the introduction of each successive critical segment adds an important increment to the muscle power of the patient. Table 1 summarizes the major muscle groups added at each critical level. Table 2 summarizes the estimated relationship between spinal cord lesion level and the functional capacity of the patient.

Table 1: Critical Levels of Function*

Deltoid, Biceps	C-5
Latissimus, Serratus, Pectoralis, Radial Wrist Extensors	C-6
Triceps, Finger Extensors and Flexors	C-7
Hand Intrinsics, Ulnar Side of Wrist and Fingers	T-1
Upper Intercostals, Upper Back	T-6
Abdominals, Thoracic Extensors	T-12
Hip Flexors, Quadriceps	L-4

*The critical muscle groups are innervated predominantly at or above the illustrated level.

This discussion is necessarily limited to the "average" patient. He is the young, well-motivated, strong patient without intercurrent disease, who has thorough training and constant practice in functional activities. All lesions are considered to be complete and sharply delineated at the discussed level. When a patient is listed as having a lesion at a given level, this is the lowest level in which all musculature remains functional. Levels will be discussed from C-5 caudad to demonstrate the functional significance of each critical increment.

Functional Capacities
C-5

The patient with a lesion just below C-5 has full innervation of the trapezius, sternocleidomastoids and the upper cervical paraspinal musculature. This combined musculature enables the patient to stabilize and rotate his neck and to elevate and rotate externally the scapulae. He also has rhomboids, deltoids, and all of the major muscles of the rotator cuff, although these are

Read at the Thirty-second Annual Session of the American Congress of Physical Medicine and Rehabilitation, Washington, D.C., September 9, 1954.

Fellow, USPHS, New York University-Bellevue Medical Center, Institute of Physical Medicine and Rehabilitation, New York City.

Director, Rehabilitation Courses for Physical Therapists, New York University-Bellevue Medical Center, Institute of Physical Medicine and Rehabilitation, New York City.

Table 2: Functional Significance of Spinal Cord Lesion Level

ACTIVITIES		C-5	C-6	C-7	T-1	T-6	T-12	L-4
Selfcare:	eating	–	±	+	+	+	+	+
	dressing	–	–	±	+	+	+	+
	toileting	–	–	±	+	+	+	+
Bed Independence:	rolling over; sitting up	–	±	+	+	+	+	+
	moving about in bed: supine and sitting	–	–	±	+	+	+	+
Wheelchair Independence: transfer from (to) wheelch.)		–	±	±	+	+	+	+
Ambulation: functional (includes to standing position)		–	–	–	–	±	+	+
Attendant:	lifting	+	+	±	–	–	–	–
	assisting	+	+	+	±	±	–	–
Homebound Work With Hands		–	–	+	+	+	+	+
Outside Job		–	–	–	±	±	+	+
Private Car		–	–	–	±	+	+	+
Public Transportation		–	–	–	–	–	±	+
Braces or Devices		Hand	Hand	Hand LLPS	LLPS	LLP ± S	LL ± P	Sh.

Hand - hand devices (splints, slings, etc.) Braces: LL: double long brace; P: pelvic band S: spinal attachment; Sh: short leg brace.

only partially innervated since they share their nerve supply with C-6. These muscles provide scapular adduction, glenohumeral abduction, internal and external rotation, as well as weak flexion and extension. The functions of strong depression, flexion, protraction, and adduction are absent at the shoulder level. Elbow flexion is possible since the biceps and brachioradialis both remain partially innervated. There is no muscular function in the wrist or hand. Unfortunately, experience has shown that the absence of shoulder primè movers (latissimus, pectoralis, serratus) and the incomplete innervation of the stabilizers prevent the remaining musculature from becoming functional. The patient cannot roll over or come to a sitting position in bed. He cannot use his hands. Only the very exceptional patient may manage some eating activities with special hand devices. He is not able to push his wheelchair. His endurance is low because of his reduced respiratory reserve.

Ambulation is, of course, out of the question and the patient is, of necessity, confined to a wheelchair. This patient relies on an attendant for a lifetime, to assist him in all self-care activities and to lift him to and from the wheelchair. To make lifting easier for the attendant, the bed is the same height as the wheelchair; the wheelchair is equipped with every possible adaptation, allowing it to be brought closer to bed, toilet or car. These adaptations are removable armrests, swinging-removable foot-rests, and detachable back. A gatch bed is used to facilitate bedcare. To compensate for the inability to stand, a tiltboard is used for at least one hour daily to maintain vascular tone and bone density.

The C-5 patient is not able to earn a living by use of his hands. If work is possible at all it will be homebound. The exceptional patient may be able to operate a specially equipped telephone business, such as selling subscriptions. However, the difficulties of keeping business records should not be overlooked. In some instances, slings or rocker splints supporting the forearm may make it possible to use an electric typewriter with the assistance of hand devices; but this kind of typing is far from functional.

C-6

A substantial functional increment is added at C-6. The rotator cuff musculature becomes fully innervated, and the

serratus, latissimus and pectoralis major receive partial, but significant, innervation. Nerve supply to the biceps is now complete. Muscles appear at the wrist, nearly always the extensor carpi radialis, and sometimes the flexor carpi radialis.

The strong rotator cuff musculature now permits good use of rotation and abduction of the glenohumeral joint. The prime movers give true adduction, flexion, extension, and scapular protraction. These functions of the prime movers are not fully developed at C-6 because of their incomplete innervation, the variability of their individual levels of major nerve supply, and the absence of good stabilization of their origins. Respiratory reserve is still low.

The biceps, of course, provide strong elbow flexion, assisted by the brachioradialis which has gained another segment of innervation. The radial wrist extensors and flexors primarily extend and flex the wrist, but the extensor has an important secondary function. The extensor can utilize the remaining elasticity of the finger flexors to produce a weak closure of the hand. Therefore, in some instances, largehandled, light weight objects can be grasped "actively"; in most cases, however, more elaborate hand devices are necessary to substitute for grasping.

Even with absent grasp the patient may take advantage of elbow flexors to sit up independently in bed, or at least to assist in this activity. He does this by pulling on a rope which is looped about his forearms and firmly attached to the foot of the bed.

The shoulder strength of the C-6 patient permits him to help in rolling over in bed. He cannot move about in bed while recumbent without aid because he cannot lift his bodyweight with his existing musculature. An occasional patient may be able to assist in lifting himself for transfer to the wheelchair. He does this by pressing his hands firmly against the supporting surface, and taking full advantage of the forcible substitution of shoulder adduction for elbow extension.

Despite this partial lifting capacity, an attendant is essential in lifting the patient to and from the wheelchair; and although the patient may feed himself with specific hand devices, and perform part of his toilet and dressing activities, a great deal of assistance is still needed. The patient cannot be regarded as independent in self care. A gatch bed is advisable to facilitate bedcare. A tiltboard is used to maintain conditioning.

Ambulation is impossible, and the patient is confined to a wheelchair. It is easier for the attendant if the bed is of the same height as the wheelchair and the wheelchair is equipped with adaptations to permit close approach to bed, toilet or car. The C-6 patient can propel his own wheelchair on smooth, level surfaces, and so can at least move from room to room by himself. Since he has no grasp, he uses elbow flexors and shoulder adductors and flexors to perform this activity, applying his thenar eminences tightly against the wheel hand rim for traction. To gain traction, hand rims are wrapped with rubber friction tape, or are provided with regularly spaced wooden or metal knobs.

A homebound job involving use of the hands is not feasible for most of these patients, although some do develop sufficient skill to use specially adapted machinery such as used for monographing or addressing. Some patients learn to type well with sticks on the electric typewriter, but complications arise in folding stationery and inserting material into the machine. Again, subscription selling by telephone may be practical, especially since record keeping is not quite as difficult as for the C-5 patient.

C-7

The patient with sparing of the C-7 segment of the spinal cord has three important functional additions: Triceps, common finger extensors, and long finger flexors. Primary innervation for each of these groups varies between C-7 and C-8 in individual cases. Significant function is usually present in each of these if C-7 is spared. The triceps is consistently strong, since it obtains some in-

nervation as high as C-6. A strong triceps enables the patient to stabilize his elbow in extension, so that the shoulder depressors now fully innervated, can act through the elbow in lifting the body weight. The advantages of grasp and release, afforded by finger extensors and flexors need not be emphasized. However this grasp and release is not powerful. The intrinsic muscles of the hand are not yet significantly innervated, and the hand lacks their flexion strength and extension dexterity.

The C-7 patient is more independent in bed and wheelchair activities than the C-6 patient. It is at this level that individual skill and coordination may allow the exceptional patient to make the transition to complete wheelchair independence. All these patients can roll over, sit up in bed, and move about in the sitting position. Assistance is still needed for most patients to lift the pelvis while recumbent, as in putting on trousers. Although most patients require help in transferring to and from the wheelchair, this help consists now of an assistive push instead of a real lift. Some assistance is still required for toileting and dressing activities. Eating can be done independently.

To facilitate the transfer from the wheelchair, the wheelchair must be fully adapted for close approach and the bed should be of the same height as the wheelchair seat. With friction tape on the hand rims, the patient can propel his own wheelchair independently for long distances on smooth surfaces, but still needs help on rough ground.

If adequately braced, some patients with a C-7 lesion are able to ambulate with crutches to some extent. The finger flexors permit grasping the crutches, and the triceps provides stability of the elbow. To maintain the upright posture the patient needs long leg braces with pelvic band and a high spinal attachment. The only independent gait possible is the "drag-to" gait.

Applying braces and attaining the erect position cannot be done without a great deal of assistance. Therefore, ambulation with these restrictions, although achieved by some patients, cannot be considered functional. However in some instances standing in parallel bars instead of standing on the tiltboard may be prescribed.

The C-7 quadriplegic is still essentially confined to a wheelchair; he needs a part-time, and in many cases, a full-time attendant. The endurance of the C-7 patient is limited by his low respiratory reserve.

Occupations requiring use of the hands are more feasible since finger flexors and extensors are functional. The type of work is limited by weakness of grasp. Therefore, activities involving tight grasp, such as leather tooling or metal work, are not recommended. Also activities requiring fine finger dexterity, such as watch-making, are not feasible. Possible vocations include bookkeeping, telephone services, mimeographing, typing, or the use of simple office machines. Outside jobs are not advisable since the patient cannot manage independently either his own car or public transportation.

T-1

The patient in whom T-1 has been spared by a complete lesion has full innervation of the upper extremity musculature, including the essential intrinsic muscles of the hand. He therefore has strength and dexterity in grasp and release, as well as fully innervated proximal musculature. The ulnar side of the wrist now has its full nerve supply, and crutch walking benefits from this addition. The patient still lacks trunk stability, respiratory reserve of intercostal origin, and trunk fixation for the origins of the upper extremity prime movers.

The T-1 patient is independent in bed activities. He is also able to transfer to and from the wheelchair without aid, although an occasional patient still needs some assistance in this procedure. The patient is independent in all activities of self care, excluding those requiring the lifting of the body while recumbent, such as putting on clothing or full-body bracing.

With functional upper extremities

and double long braces, pelvic band and high spinal attachment, the T-1 patient can do a "drag-to" or "swing-to" gait. Because of full body-bracing, attaining the erect position is a very laborious procedure requiring a great deal of help. Therefore ambulation usually cannot be considered functional, but is prescribed for exercise purposes. A well-adapted wheelchair allowing close approach to the bed, which is the same height as the wheelchair is still essential.

Homebound jobs involving use of the hands are practical. There is no limit for sedentary jobs for the T-1 patient, or for any patient with a lesion below this level. Employment outside the home is possible, provided somebody can drive the patient to and from work. Some patients develop sufficient sitting balance to drive a hand-controlled car. Although they are able to transfer independently from wheelchair to car, they still need help to lift the wheelchair in and out of the car.

T-6

The T-6 paraplegic presents one major functional gain over the T-1 patient in that he has a complete, strong chain of upper extremity and thoracic musculature, stabilized against a well-coordinated pectoral girdle. Innervation is now supplied to the long muscles of the upper back, and to the upper intercostals and transversus thoracis. The patient thus has a tight grasp, supported by proximal musculature which in turn is stabilized against a thorax which can be fixed for heavy lifting. Added intercostal innervation gives the patient an increment of respiratory reserve which increases his endurance.

These functional additions are enough to provide independence in all phases of self care. Even the application of full body bracing becomes possible; the patient can adequately stabilize his upper extremities to use them to lift the pelvis in applying braces while recumbent. Independent transferring to and from the wheelchair becomes easily possible by using the strong pectoral girdle and triceps. Consequently the patient usually needs no attendant. The wheelchair should still be adapted as heretofore described.

The patient is braced with a low spinal attachment, pelvic band and double long leg braces. With this bracing the patient is able to stand erect for indefinite periods. He is also able to ambulate once he has reached the erect position. Because of his strong, stabilized upper extremities he is capable of doing an independent "swing-through" gait. However, "swing-to" remains the safer and more practical gait. Unfortunately the use of ambulation is restricted by the slow and laborious attainment of the erect position. Only the exceptional patient, who develops unusually strong upper extremities with good balance and coordination, will use his ambulation functionally on level ground or inside the house.

To assist the patient in attaining the erect position, and thus encourage ambulation, such aids as door-bars, parallel or stall bars are prescribed for the home. Even if ambulation is not used functionally, the patient is encouraged to stand for at least one hour daily, instead of standing on the tiltboard as used for higher lesions. Some patients report they feel more comfortable while standing and prefer to do some of their work standing up. For these patients, special standing adaptations of work equipment are encouraged.

Elevation activities are markedly impaired. Since hips and knees are locked, all elevation must be accomplished by pure push-up in the shoulder girdle. This push-up is adequate in most patients only for the ascent of very low stairs with a handrail. The patient can neither ascend standard eight-inch stairs even with a handrail, nor climb curbs. Public transportation is therefore impossible. Work, outside the confines of the home, can be reached by private hand-controlled or chauffered car. The patient is able to transfer independently from his wheelchair to the car. Most patients with a T-6 lesion have sufficient sitting balance to drive a hand-controlled car, and some manage to

place their wheelchair in and out of the car. The job must remain sedentary in nature with the possible standing modifications described.

T-12

The T-12 patient has full innervation of the rectus abdominis, the oblique muscles of the abdomen, the transversus abdominis, and all muscles of the thorax. There is still weakness of the low back where lumbar musculature is not innervated. The patient does not have innervation of the primary hip hikers (quadratus lumborum) and lower erector spinae. Hip hiking can be accomplished with relative ease by the secondary hip hikers, including the internal and external obliques and the latissimus dorsi. With this musculature the patient becomes independent in self care, wheelchair and ambulation.

The patient is braced with bilateral long leg braces, and may or may not have a pelvic band, depending on his skill in ambulation. He can use a "two point alternate," "four point," or "swing-through" gait as suits his convenience. "Four point" and "two point alternate" gaits are achieved through the use of the secondary hip hikers. Using all these gaits the patient is usually independent in ambulation. He can ambulate freely on reasonably rough surfaces, inside or outside. He can also negotiate curbs, either backwards by swinging the leg up (the hip joints now being free anteroposteriorly) or forwards by swinging up as part of a continuous "swing-through" gait.

Due to the ability of the patient to tilt his pelvis he can easily negotiate standard eight inch stairs with a handrail. The formidable bus steps can be climbed laboriously. This enables the patient to take public transportation, but use of a private car is more practical. Of course, rush hour travel is never included in any discussion of public transportation for paraplegics.

The T-12 patient has very few vocational limitations in sedentary or semisedentary jobs away from home. Even entrance ramps or stairs at the place of employment are no longer contraindications to placement. The patient needs no attendant, and often needs no wheelchair during the course of the day's work. However, for convenience in moving about at home (for instance, to and from the bathroom), a wheelchair is always prescribed. The adjustment of the chair is determined by the demands of the home. Some patients will also take their wheelchair to work for convenience.

L-4

The patient with a lesion just below L-4 has the added functional assistance of the quadratus lumborum, lower erector spinae, quadriceps and primary hip flexor. The major stabilizers of the hip are absent, and the ankle remains flail. These factors predetermine the patient's gait and his bracing. The knee is supported in extension by the quadriceps so that long leg bracing becomes unnecessary. The flail ankles must still be supported; a short leg brace is used for this purpose. It is advisable in most cases to use a limited motion stop (allowing about fifteen degrees of motion, all in dorsiflexion); the posterior stop serves as a support to prevent footdrop during the swing phase of gait. The anterior stop substitutes in an admittedly meager fashion for the stabilizing effect of the calf musculature during push-off.

The patient's gait is a bilateral "maximus-medius" gait, with the added disability of absent hamstrings and flail ankles. This produces a number of deforming factors. The lack of maximus and hamstrings causes the patient to snap back sharply against the anterior hip ligaments shortly after heelstrike. To do this he must maintain the knee in tight extension; this extension of the knee in the absence of hamstrings tends toward the production of recurvatum. Also, the necessity to keep the pelvis extended against the anterior hip ligaments produces a lumbar lordosis which is eventually deforming in nature.

A patient with the foregoing described musculature and gait could be completely independent without crutches or

canes. However, because of the long-term deforming effects of the unsupported gait, bilateral canes or crutches are usually prescribed prophylactically. By minimizing the extremes of lateral and posterior swings of the pelvis, and through careful gait training, both the lumbar lordosis and recurvatum can be reduced. This reduction of deforming forces serves as protection against the later development of lumbar root compression or traumatic arthritis of the knee.

The L-4 patient is completely independent in all phases of self care and ambulation. His major limitations are in elevation. Because of absent gluteus maximus and hamstrings, he must do his elevation with his quadriceps; this is difficult, but can be accomplished with the assistance of a hand firmly applied to the anterior thigh, or with a handrail, crutch or cane. Canes with support above the wrist (such as the Lofstrand) are advisable since the standard wooden cane does not provide sufficient upper extremity stability. A wheelchair is still convenient at home, and may be in certain job situations. Job limitations are still present. The patient cannot be expected to stand for great lengths of time. Employment requiring constant rising from a chair, or a great amount of elevation activities, is definitely not advisable.

Summary

The correlation between spinal cord lesion level and functional capacity is discussed. In the absence of medical and psychiatric complications, the most important factor in this relationship is the distribution of the remaining muscle power. Early in the course of rehabilitation, functional goals can be outlined in general on the basis of the remaining muscle power. However, the great individual differences cannot be overlooked. Spasm, urinary infection, lack of coordination and lack of motivation are some of the most common restricting factors which may occur. A patient with any one or more of these complications may reach a more limited goal than another patient with less muscle power and no complications. Thorough training and constant practice in functional activities are essential for all patients.

The patient with a cervical lesion has partial strength in his upper extremities. He may groom and feed himself, but usually requires a full-time attendant for all other activities. He is confined to a wheelchair and to a homebound job.

The patient with a high thoracic lesion has full upper extremity strength and is independent in transfer to and from the wheelchair, and in self-care activities. He may walk with help if fully braced, but in most instances cannot use his ambulation functionally. Primarily he remains a wheelchair patient and may require a part-time attendant. A homebound job is most practical.

The patient with a mid-thoracic lesion has good upper extremities and thoracic stabilization. He is independent in self-care and wheelchair activities. Although he can ambulate on level ground, it is more practical for him to use a wheelchair, in which he can work away from home.

The patient with a very low thoracic lesion has good upper extremities, thoracic and abdominal strength. He is completely independent in self-care and wheelchair activities. If adequately braced he can ambulate, climb stairs and curbs, enabling him to secure employment outside the home.

The patient with a low lumbar or sacral lesion has full upper extremity and trunk strength, hip flexors and knee extensors. His bracing is minimal. He is completely independent in all activities. His job is limited only by moderate deficiencies in ambulation and elevation activities.

Reference

1. McDonald, Joseph J., and Chusid, Joseph G.: Correlative Neuroanatomy and Functional Neurology, California, Lange Medical Publications, 1952.

For reprints, write Dr. Long, Chief, Division of Physical Medicine and Rehabilitation, Henry Ford Hospital, Detroit, Mich.

Editorial Board Adds New Members

Arthur C. Jones, M.D.

Paul A. Nelson, M.D.

The *ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION* is pleased to announce the addition of two members to the Board — Arthur C. Jones, M.D., of Portland, Ore., and Paul A. Nelson, M.D., of Cleveland. Dr. Jones was appointed the seventh member of the recently enlarged Editorial Board. Dr. Nelson is filling the vacancy created by the death of Dr. Walter M. Solomon.

Dr. Jones, who was certified by the American Board of Physical Medicine and Rehabilitation in 1947, is Director of the Departments of Physical Medicine and Rehabilitation at the University of Oregon Medical School and the Good Samaritan Hospital. He is fourth vice-president of the Congress and is a member of the Congress committees on Gold Key Award and Legislation, as well as the Society committee on the Survey of Economic Status of Physiatrists for 1955.

Dr. Nelson, a diplomate of the American Board of Physical Medicine and Rehabilitation since 1952, is a staff member of the Cleveland Clinic Foundation and medical director of the physical therapy course at Frank E. Bunts Educational Institute which is affiliated with the clinic. For 1955, he is serving on the Congress committee on Advances in Education.

In addition to being active Congress members, both are members of the American Society of Physical Medicine and Rehabilitation; American Medical Association, and the American Rheumatism Association.

MEDICAL NEWS

Members are invited to send to this office items of news of general interest, for example, those relating to society activities, new hospitals, education, etc. Programs should be received at least six weeks before the date of meeting.

National Advisory Council Appointed

Appointment of twelve members of a National Advisory Council on Vocational Rehabilitation, established under the Vocational Rehabilitation Act of 1954, was announced by Oveta Culp Hobby, Secretary of the U.S. Department of Health, Education, and Welfare.

Miss Mary E. Switzer, Director of the Office of Vocational Rehabilitation, will chair the Council, which is authorized under the law to review or to recommend initiation of applications for grants for special projects which show promise of making valuable contributions to the vocational rehabilitation of physically handicapped individuals.

The members were selected, Mrs. Hobby stated, both to meet the statutory requirements and also because of their long interest and activity in behalf of handicapped people.

"We expect the Council to render an important service to the handicapped people of our nation under President Eisenhower's program for a greatly expanded and improved system of vocational rehabilitation," Mrs. Hobby said. "Its members bring outstanding and varied records of accomplishment in medicine, rehabilitation, education, public relations, labor and management to their task of advising on special projects involving activities in all of these fields."

All terms of members eventually will be of four years duration, with initial appointments made for varying terms to provide for annual changes of membership. The appointments are:

Four-year terms: Dr. Theodore G. Klumpp, President, Winthrop-Stearns Inc., drug manufacturers, New York City: Peter J. Salmon, Executive Director, Industrial Home for the Blind, Brooklyn, and Eugene J. Taylor, Assistant Professor of Clinical Medicine and Rehabilitation, New York University College of Medicine, New York City.

Three-year terms: Catherine B. Cleary, Vice-President, First Wisconsin Trust Company, Milwaukee, Wis.; Dr. Henry H. Kessler, Director, Kessler Institute for Rehabilitation, West Orange, N. J., and Eli Gorodezky, attorney, Phoenix, Ariz.

Two-year terms: James. A. Brownlow, President, Metal Trades Department, American Federation of Labor, Washington; Voyle C. Scurlock, State Director of Vocational Rehabilitation, Oklahoma City, and Louise Baker, author, Lincoln, Neb.

One-year terms: Graham H. Anthony, Chairman of the Board, Colt Manufacturing Co., and Chairman of the Executive Committee, Veeder-Root, Inc., Hartford, Conn.; Henry Viscardi, Jr., President and Chairman of the Board, Abilities, Inc., West Hempstead, N. Y., and Robert E. Cammack, State Director of Vocational Education, Montgomery, Ala.

Personals

The Academy of Medicine, at Harrisburg, Pa., heard **Herman L. Rudolph**, Reading, speak on "Common Problems More Adequately Treated with Physical Medicine as an Adjunct" at its February meeting. — **Lee B. Greene**, Bridgeport, Conn., formerly Chief of Outpatient Department of Institute of Physical Medicine and Rehabilitation, is now Director of Physical Medicine and Rehabilitation, Woodruff Restorative Center, New Haven, and Hillside Home and Hospital, Bridgeport, Conn. Dr. Greene is attending consultant to West Haven VA Hospital. He addressed the Gray Ladies of Bridgeport Red Cross on January 19, his topic being "Therapy for the Aged." — The subject "Some Treatment Aspects of Cerebral Palsy" was delivered by **S. Malvern Dorinson**, San Francisco to the Parents Group at Bakersfield and San Francisco. — **Karl E. Carlson**, Palo Alto, has been appointed regional consultant in Physical Medicine and Rehabilitation to the regional office of the VA at San Francisco. — "The Outlet Syndrome" was presented by **Paul A. Nelson**, Cleveland at the postgraduate course, Frank E. Bunts Educational Institute, February 9 and 10. — **Bernard Stoll**, formerly of Chicago, has been appointed Chief of Physical Medicine and Rehabilitation, Manhattan VA Hospital, New York City. — The New York Chapter of Rehabilitation Therapists elected **Jerome Weiss**, Brooklyn and **Alfred Ebel**, Bronx, to serve on the Medical Advisory Board. —

George G. Deaver, New York City, has been awarded the Citation for Outstanding Service of the Governor's Committee on Employ the Physically Handicapped. Dr. Deaver will receive the citation at the annual meeting of the Medical Society of the State of New York in May. — At the three-day institute on Adapted Physical Education, sponsored by The Association for Physical and Mental Rehabilitation in conjunction with the New York University School of Education, **Otto Eisert**, Brooklyn, presided over a panel discussion on "Corrective Therapy for the Psychiatric Patient." **Jack E. Meislin**, Montrose, N.Y., showed the relationship of psychiatry to physical education. — Presiding over a discussion of "Corrective Therapy for the General Medicine and Surgical Patient" was **Joseph Rogoff** of Brooklyn. — **George H. Koepke**, Ann Arbor, Mich., was recently appointed assistant professor in the Department of Physical Medicine and Rehabilitation, University of Michigan Medical School.

Recent Publications by Members

Howard F. Polley, with co-authors, "The Effects of Aldosterone (Electrocortin) and of 9a-Fluorohydrocortisone Acetate on Rheumatoid Arthritis: Preliminary Report." Proceedings of the Staff Meetings of the Mayo Clinic, December 22, 1954.

Otto Glasser, "Human Side of Science," chapter in "The Doctor Writes" by S. O. Waife, New York, Grune & Stratton, 1954.

Allen S. Russek, "Role of Physical Medicine in Relief of Certain Pain Mechanisms of Shoulder." The Journal of The American Medical Association, December 25, 1954.

Herbert Kent, "Functional Brace for the Paralyzed Hand." The Journal of Bone and Joint Surgery, October, 1954.

Murray B. Ferderber, with co-author, "An Effective Comprehensive Program for Geriatric Patients." The Journal of the American Medical Association, January 29, 1955.

The following paper and editorial were published in the February, 1955 issue of Journal of Chronic Diseases:

Harold N. Neu and Harold A. Ladwig, "Medical Management of the Long-term Respirator Patient."

Howard A. Rusk, with co-author, "Economic Values of Rehabilitation."

The following papers were published in the February 5, 1955 issue of The Journal of The American Medical Association:

Edward W. Lowman, "Osteoarthritis."

Howard F. Polley, with co-author, "Medical Treatment of Osteoarthritis."

Frances Baker, "Physical Medicine in Treatment of Degenerative Joint Disease."

The following papers were published in the January, 1955 issue of Department of Medicine and Surgery Information Bulletin:

Ray Piaskoski, Edwin C. Welsh, with co-authors, "Cardiac Rehabilitation Program at the VA Center, Wood, Wisconsin."

Harry T. Zankel, "The Physical Medicine and Rehabilitation Bed Service, VA Hospital, Cleveland, Ohio."

Maxwell D. Flank, with co-author, "Short Ladder Attachments for Parallel Bar Walking Ramp."

Institute Visited by Cardiologists

A group of cardiologists who had been attending the World Congress of Cardiology visited the Institute of Physical Medicine and Rehabilitation, New York City. The following staff physicians spoke to the group: Joseph Benton on "Rehabilitation of Patients with Cardiovascular Disease"; Donald Covalt on "Treatment Procedures for the Patient with Hemiplegia"; Joseph Goodgold on "Diagnostic Procedures in Peripheral Vascular Disease" and Allen Russek on "Site of Amputation for Vascular Disease of the Lower Extremities."

Southern Section of Congress Meets in Houston

On February 26, the Southern Section of the Congress held a meeting in Houston, Texas. The following members participated: Sol Winokur spoke on "Clinical Experiences and Impression in the Use of Ultrasonics"; Lewis A. Leavitt chose as his topic "Clinical Electromyography"; Vann S. Taylor and Edward M. Krusen were members of a panel on Training of PM&R Ancillary Personnel. "Vocational Rehabilitation of the TB Patient" was delivered by Howard L. Schnur; Lt. Col. John H. Kuitert spoke on "Current Status of the Cineplastic Procedure as Physical Rehabilitation for the Amputee." Oscar O. Selke, Jr. presided at the banquet and the dinner address "Physical Medicine: Then and Now" was presented by Nathan H. Polmer.

Second International Congress of Physical Medicine

The Second International Congress of Physical Medicine, scheduled for Copenhagen, Denmark, August 20-24, 1956, has the following program planned:

The Physiology of Heat Regulation and Temperature and Their Relation to Peripheral and Central Circulation as Basic Problems Within Physical Medicine;

Applied Physiology of the Striated Muscle as Basic Discipline Within Physical Medicine;

Physiology, Diagnostic Significance and Therapy of Pain in Relation to Physical Medicine, and

Rehabilitation on a Scientific Basis, Es-

pecially with a View to the Pathophysiology of Muscle and Evaluation Assessment.

Direct all inquiries to Hon. Secy. B. Strandberg, M.D., Kobenhavns Amts Sygehus I Gentofte, Dept. of Rheumatology and Physical Medicine, Hellerup, Denmark.

Medical Quackery Increases

The Commissioner of the Food and Drug Administration recently warned of an increase in fake medical products and devices. He pointed out that sufferers from chronic ailments continue to be the victims of "high-powered hocus pocus research." The most serious exploitation is in the field of cancer quackery.

Colleges Helped by GE

General Electric has announced its plan for assisting colleges financially. The G.E. Educational Fund will duplicate every gift made by a G.E. employee to an accredited four year U.S. college or university at which he has earned a degree. The fund will make its matching gift to the same school on a dollar-for-dollar basis up to $1,000 in one year.

PHYSICAL MEDICINE ABSTRACTS

Effect of the Oscillating Bed and Tilt Table on Calcium, Phosphorus and Nitrogen Metabolism in Paraplegia. D. M. Wyse, and C. J. Pattee. Am. J. Med. 17:645 (Nov.) 1954.

Paraplegia is followed by metabolic changes characterized by disuse osteoporosis, hypercalcinuria and negative nitrogen balance. The disuse osteoporosis has been postulated by Albright to be due to failure of osteoblastic activity, resulting from lack of "stresses and strains" on bone. These might consist of direct weight bearing through bone, circulatory changes in bone or muscular pulls on bone, acting either singly or in combination. The metabolic changes, notably in calcium metabolism, occurring in a paraplegic patient have been found to return to normal only upon ambulation. Therefore, an attempt was made in five paraplegic patients to imitate ambulation while the patient was still immobilized, by use of the oscillating bed, postulated to produce circulatory changes, and by the tilt table, postulated to produce direct weight bearing through bones. The planned length of study was forty-eight days. Studies of calcium balance and x-rays failed to reveal any significant effect from these procedures either on the osteoporosis or hypercalcinuria. No significant effect on nitrogen or phosphorus metabolism, basal metabolic rate, renal function tests or urinary 17-ketosteroids were observed by use of the oscillating bed or tilt table.

It is postulated that the "stresses and strains" on bone might result primarily from muscular contractions rather than weight bearing or circulatory changes.

Arteriosclerotic Muscular Rigidity with Special Reference to Gait Disturbances. W. Bruetsch, and C. Williams. Am. J. Psychiat. 3:332 (Nov.) 1954.

Arteriosclerotic muscular rigidity was first described by Foerster in 1909. The syndrome consists of a progressive muscular rigidity, slowness of movements, various types of gait disturbances and mental deterioration. This article is the clinico-anatomic report of two such cases.

The rigidity involves practically all voluntary muscles of the body. The affected muscle groups appear hard to the touch. The rigidity is very marked; in turning the patient in bed, the body can be rolled over like a log of wood. As time goes on, the rigidity increases until the patient lies helplessly in bed. The muscular rigidity is the basic cause for the slowing of all motions; fast movements can no longer be executed. Later fine movements are impossible. An early symptom is the disturbance of gait. This is characterized by the small steps and ataxia. Eventually the patient can neither stand nor walk. Almost any type and degree of mental abnormality may be present. Postmortem microscopic examinations revealed innumerable small areas of softening in the white matter

of the hemispheres, including the corpus callosum. Specifically, they were found in the fibers of corona radiata, the striate bodies, the internal capsule, the optic thalami and the pons. The pontine lesions involved the fibers of the pyramidal and of the fronto-ponto-cerebellar tracts.

In summary, the authors conclude that the syndrome of arteriosclerotic muscular rigidity results from a partial involvement of various systems (fronto-porto-cerebellar tract, pyramidal and extrapyramidal system) rather than from an affection of one or two special cerebral centers.

Two Joint Muscles of the Thigh. J. C. E. Markee, et al. J. Bone & Joint Surg. 37A:125 (Jan.) 1955.

The authors have studied the morphology of the two joint muscles of the thigh: the rectus femoris, the semitendinosus, the semimembranosus, the biceps femoris, the sartorius, and the gracilis. In human material supplemented by functional studies on muscles of dogs, evidence indicates that all of the muscles during contraction can produce tension at one joint only. Movement can be produced in the hip without movement of the knee by a part of the rectus femoris, sartorius, gracilis, semitendinosus, semimembranosus, and biceps femoris. Movement at the knee can be produced without movement of the hip by the gracilis and the biceps femoris. Tension producing movement of two joints is transmitted by the tendinous attachments to bone. Muscle tension resulting in movement at a single joint is transmitted by fascial connections. Coordination of motion at the hip and the knee may result in more efficient utilization of muscular energy. The demonstration of the importance of fascial connections along the length of a muscle to assist in control of muscular activity is an important contribution to kinesiology. This study points up the need for further experiments on the relationship of aerolar connective tissue as a mediator of tensions produced by muscular contracture.

Infrared Spectroscopic Studies of Pigmented Skin Tumors. E. P. Cawley, et al. A.M.A. Arch. Dermat. & Syph. 70(6):748 (Dec.) 1954.

The infrared spectrometer is a physical tool which is used for measuring and recording the infrared transmission and absorption of solids, liquids, and gases. The infrared spectrum of a compound is a function of its chemical composition, and results from selective absorption by the compound at certain frequencies in the infrared portion of the electromagnetic spectrum. The infrared portion of the electromagnetic spectrum extends from about 0.75 micron to about 350 microns, the range from 2 to 16 microns being most informative. The objective of the authors was to study the infrared transmission and absorption of pigmented skin tumors in the region of 2 to 16 microns.

Although it was not possible to appraise completely and precisely the infrared spectrums of the pigmented skin tumors, because of inherent complexities in their chemical composition, several findings of interest were noted. It appears that nucleic acids are present in many highly cellular tissues in adequate concentration to cause significant infrared absorption in the region of 8 to 11 microns. Malignant melanomas contained more of these compounds than other lesions examined in the course of this investigation.

Hyalurodinase in the Treatment of Acute Sprained Ankle. P. Hume Kendall. Ann. Phys. Med. 2(3):95 (July) 1954.

Hyalurodinase is widespread throughout the body, forming the principal component of intercellular ground substance and being largely responsible for maintaining the viscosity of synovial fluid. When introduced into tissues, it acts to break down ground substance and cause a freer flow and rapid absorption of intercellular fluids.

This report summarizes the results of treatment of 27 cases of acute sprained ankle with hyalurodinase. In all cases, severe ligamentous tears and bone injury of any kind were excluded by clinical and radiological examination. The criteria for recovery were freedom from pain; absence of swelling, and normal gait. The results were compared with those of a control series of ninety-two similar cases, seventeen of which were given surged faradism, effleurage and exercises, twenty-five of local injection of two per cent procaine, twenty-five immobilization in adhesive strapping, and twenty-five receiving no treatment.

A dramatic reduction in swelling was observed in the majority of cases treated by use of hyalurodinase. The recovery time in this group was 3.1 days as compared to 8.7 to 13.9 days in the control groups. No side effects were observed.

A Physiologic Evaluation of the Effects of Diaphragmatic Breathing Training in Patients with Chronic Pulmonary Emphysema. William F. Miller. Am. J. Med. 17(4):471 (Oct.) 1954.

The principal objective of this investigation was to determine the specific benefits of diaphragmatic or abdominal breathing exercises used over a period of eight weeks in the treatment of asthma and emphysema. The objective approach became necessary because of the difficulty in evaluation of subjective responses.

Increased diaphragmatic excursion, accomplished by training, resulted in a striking increase in tidal volume at a lower respiratory rate and respiratory midposition. As a result of these changes, more effective alveolar ventilation was accomplished without significant increase in total ventilation, except in those instances in which it was decreased prior to training. Improved alveolar ventilation was indicated by the increased rate of removal of O_2, increased arterial oxygen saturation, decreased arterial pCO_2, and increased exercise tolerance with less dyspnea.

Clinically, it is apparent that effective diaphragmatic training results also in a more effective cough mechanism with improved evacuation of bronchial secretions.

Effect of Rest and Activity on the Serum Protein Fractions. T. P. Whitehead, et al. Am. J. Clin. Path. 24:1265 (Nov.) 1954.

This paper is a report of an investigation to determine if any precautions had to be taken with regard to the posture of patients in the period before blood was withdrawn for analysis of serum albumin and globulin. This could have importance when comparing the levels of serum protein of a group of patients confined to bed with those of a group of ambulatory patients.

Early work on the alterations of total serum protein, hemoglobin and hematocrit values with changes in posture of the body was confined almost completely to experiments with short intervals of time between changes of posture, and usually under conditions not likely to be met with on the wards or outpatient departments of the hospitals. Fifteen normal persons between 21 and 65 years of age were studied; there were ten men and five women. Two specimens of venous blood were collected from each person; one at 8:00 a.m. after the patient had been in bed for nine hours and one at 4:00 p.m. after being up and about for eight hours. In the latter, the activity was not restricted but extremes such as heavy work and long rest periods were forbidden. The hematocrit, hemoglobin, total serum protein and serum protein fractions including albumin, alpha globulin, gamma globulin and beta globulin, were obtained on the patients. All chemistry values were determined by accepted standard laboratory procedures. The method of statistical analysis was that of paired comparison between the 8:00 a.m. and 4:00 p.m. results. Analysis of the statistical significance of the difference between the 8:00 a.m. and 4:00 p.m. values showed that the alterations in albumin and total protein were highly significant. Alterations in values for hemoglobin, hematocrit and the three globulin fractions were not statistically significant.

The authors conclude with the statement that they have found no completely satisfactory explanation for the increase in serum albumin but this increase in serum albumin may be of considerable importance in comparing the protein levels of patients confined to bed with those of ambulatory persons.

REMEMBER!

It's not too early to make plans for the annual meeting in Detroit.

For Muscle Stimulation

MAJESTIC "M-100"

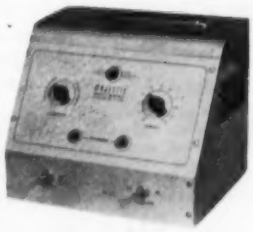
VARIABLE FREQUENCY GENERATOR

PULSATING - SURGING - TETANIZING

Muscle stimulating current fully adjustable from approximately one pulse per second to full tetanizing current. Life time Synchron timing motor.

$119.50

COMPLETE



WRITE FOR COMPLETE CATALOG

MAJESTIC SURGICAL INSTRUMENT CO., 4207 W. Lawrence Ave., Chicago 30, Ill.

PRESTON

A Complete Line

FOR PHYSICAL MEDICINE AND REHABILITATION

REHABILITATION: Walking Parallel Bars and Exercise Staircases of various designs; Posture Mirrors, single & triple; Gymnasium Mats in various thicknesses and coverings; Bicycle Exercisers; Restorator; Progressive Resistance Exercise Units; Quadriceps-Gastrocnemius-Footdrop Boots; Dumbbells; Indian Clubs; Wall Pulleys; Door Pulley Assemblies; Guthrie-Smith Suspension Apparatus; Stall Bars; Shoulder Wheels with height adjustment; Manuflex, Kanavel Table; Sayre's Headslings; Ankle Exercisers; Treatment Tables; Timers.

HYDROTHERAPY - ELECTROTHERAPY: Whirlpools for every use; Hubbard Tanks; Paraffin Baths; Hydrocollator; Shortwave Diathermy; Galvanic - faradic - sinusoidal Generators; Ultraviolet Lamps; Infrared Lamps and Bakers; Ultrasonic Generators.

DIAGNOSTIC APPARATUS: Chronaximeters; Dynamometers; Goniometers; Oscillometers; Thermocouples and Skin Thermometers.

INVALID EQUIPMENT: Everest & Jennings Wheelchairs; Hollywood Wheelchairs; Commodes; Walkers; Patient Lifters; Standing (Tilt) Tables; Stretchers; Largest selection of Crutches and Canes.

COMPLETE LINE OF CEREBRAL PALSY FURNITURE AND EQUIPMENT - SPEECH THERAPY - SELFHELP DEVICES.

New Items of Interest

Literature Upon Request

Guthrie-Smith Universal Sling Suspension Apparatus. Standard and Portable Models; complete with all springs, ropes, pulleys, slings, etc.....$295.00

Standing Table. Manually operated; movable footrest; Tilts up to 70°. Supplied with safety belts. Price including casters.....$190.00

Write for your free copy of illustrated Catalog No. 1054. Inquiries Invited.

ALL your needs supplied by ONE reliable source

J. A. PRESTON CORP.

175 FIFTH AVENUE, NEW YORK 10, N. Y.

MOISTAIRE

The Original Heat Therapy Unit

UNEXCELLED

for the delivery of moist heat at the exact prescribed temperature.

COMFORT • SAFETY • DURABILITY

MOISTAIRE accepted and approved since 1944 by the Council on Physical Medicine and Rehabilitation (AMA) and Underwriters' Laboratories.

For illustrated information write, wire or call:

The **RIES** *Corporation*

515 SOUTH AIKEN AVE., PITTSBURGH 32, PA.

POSEY PATIENT SUPPORT

Get your patient out of bed for wonderful psychological effect. As patient cannot fall forward the constant attention of attendant is not required. For use in both wheel chair and conventional-type chairs.

Posey Patient Support No. PP-753, white, $5.85.

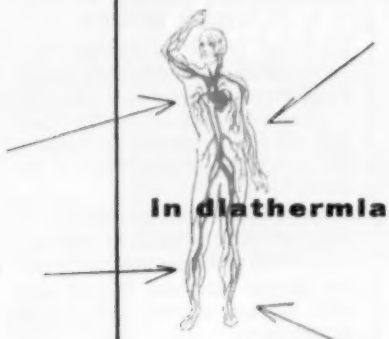
Adjustable shoulder strap model PP-154, $7.50 each.

J. T. POSEY COMPANY

801 N. Lake Avenue, Dept. PMR

PASADENA 6, CALIFORNIA

these units are the *criterion*



in diathermia and ultra sonics

MODEL 3000 ULTRA SOUND

Two ultra sound machines are manufactured by the pioneer R. A. FISCHER & CO., leader in electro-therapy equipment. Shown is the Model 3000 Console, one of the finest units presently available. Model 3000 offers CONTINUOUS ULTRA SOUND plus **IMPULSE ULTRA SOUND** (successful treatment without heat). Companion to the Model 3000, the Model 2500 Portable is not illustrated. Both units reflect outstanding craftsmanship—each is guaranteed a full year. Contemporary cabinets are finished in off-white enamel and in gray hammertone metallic, with special colors on request. The 3000 unit sells for $495.00 and the Model 2500 is $345.00 (FOB Glendale, Calif.). Further details will be sent immediately on your request.

MODEL 1200 MASTER FISCHERTHERM

In diathermia no machine surpasses the performance of the Model 1200 CONSOLE MASTER FISCHERTHERM. Power output is more than ample for heaviest therapeutic demands. The cabinet is finished in off-white enamel and in gray hammertone metallic—special metallic finishes in shades of maroon, blue or green are available on request. The hinged electrode set (Catalog No. 1202) is purchased separately at $109.00. Price of the MASTER FISCHERTHERM Model 1200 is $654.50 FOB Glendale, California. A full year guarantee, of course. Your request for details will be promptly handled by our office staff.

R. A. FISCHER & CO.

Manufacturers of Electro-Therapy Equipment

525 Commercial Street, Dept. A • Glendale 3, California

FISCHER

LUXOR ALPINE QUARTZ LAMP

Delivers complete ultraviolet spectrum required for general therapeutic use. Starts instantly at snap of switch, provides intense radiation and an even distribution over a wide, shadowless surface. Low in cost, easy and economical to operate.

ULTRAVIOLET THERAPY

ESSENTIAL AND VALUABLE ADJUNCT IN PHYSICAL MEDICINE

Ultraviolet, recognized ancillary treatment in physical rehabilitation, speeds convalescence. Particularly effective in increasing blood hemoglobin level, and improving utilization of calcium, iron, nitrogen, and phosphorus in the blood.

For 50 years, Hanovia scientists and engineers have made basic contributions to the vast improvement in physical therapy equipment to keep pace with modern science and clinical requirements.

HANOVIA Chemical & Mfg. Co.
100 Chestnut St., Newark 5, N. J.

AERO-KROMAYER QUARTZ LAMP

Intense, concentrated source of ultraviolet for local and orificial application. Provides the most minute and accurate control of any required degree of clinical actinic reaction on skin surfaces or within the body cavities. Air-cooled! Operates effectively in every position.

YOURS ON REQUEST: Interesting brochure describing curative effects of ultraviolet radiations. Send for your free copy today. Write to DEPT. PMR-4

50th Anniversary
HANOVIA WORLD LEADER
IN ULTRAVIOLET FOR HALF A CENTURY

No other medical periodical gives you such "wide coverage" in the field of physical medicine and rehabilitation as THE ARCHIVES

If you are a teacher of physical medicine, a research worker, a physicist, or just a clinician—if you want to stay abreast of all that is new in physical medicine and rehabilitation — you *must* read THE ARCHIVES.

Each month you will find in this journal informative articles, constructive editorials, physical medicine news, announcement of new books and a wealth of abstracted material dealing with every phase of physical medicine and rehabilitation.

If you are not a subscriber to THE ARCHIVES — send in your subscription today. Sample copy will be sent on request. Subscription price $7.00 per year; Canada, $8.00; elsewhere, $14.00 the year.

AMERICAN CONGRESS OF PHYSICAL MEDICINE AND REHABILITATION,
30 No. Michigan Ave., Chicago 2.

Please find enclosed check for $7. ☐ or bill me ☐ for one year's subscription to the ARCHIVES.

Name .....

Address .....

City, Zone and State.....

ANNOUNCING

the New Medi-Sonar Portable

ULTRASONIC GENERATOR

This unprecedented new Model 1100 *PORTABLE* MEDI-SONAR Ultrasonic Generator is unquestionably the finest instrument available anywhere at any price. Its claim to *absolute superiority* rests in several extremely important factors, most of which are exclusive with Dallons. Its incomparable quality gives more dollar-for-dollar value... more power, better control, finer engineering. Price, complete **$535.00 f.o.b. Los Angeles**

Dallons 1st IN ULTRASONICS

- "Console" quality and output at "portable" prices.
- Guaranteed minimum output total of 20 watts—Actual output, not just rated.
- Larger precision-ground quartz crystal—10 sq. cm.
- Specially designed safety transducer.
- Dual-scale meter for "at-a-glance" direct reading of total watt output and watts per sq. cm.
- Stepless output control for accurate dosage duplication.
- Even distribution of energy at low temperatures in full cylindrical pattern.
- Resonance control for positive tuning under all conditions.
- All metal, well ventilated, case with protective cover.
- Written one year guarantee on both machine and transducer.
- Made under U.S. Patents, U/L inspected and approved, CSA approved, and Certified under FCC regulations.

Professional Literature on Request

DALLONS LABORATORIES, INC.

"Superior Equipment for Superior Performance"

5066 Santa Monica Blvd., Los Angeles 29, Calif.

FILL OUT AND MAIL THIS COUPON TODAY

Please send full information

NAME _____

STREET _____

CITY _____ STATE _____

☐ Send Literature ☐ Have Representative Call

"The Devil was having wife trouble"

"HERE I AM, twenty-four years old and what have I done?" he had once written. But he was 53, and his face, like his indomitable will, had become seared and toughened by years of Arctic struggle before he reached his ultimate goal.

On December 15, 1909, Robert E. Peary, standing where no man had set foot before, planted the American flag on the North Pole.

His return to his base was so uneventful one of his Eskimos said the Devil must have been asleep or having trouble with his wife.

Actually, good luck of this sort was a rarity to Peary. He had failed six times before to reach the Pole, but he never gave up. He lived all his life by his motto: *I shall find a way or make one.*

Peary's was a motto Americans find easy to understand. In fact, it typifies the practical "strike-out-for-yourself" spirit of the 160 million American citizens who stand behind United States Series E Savings Bonds. Perhaps that's why these Bonds are among the finest investments in the world today. For your personal security—and your country's—why not invest in them regularly!

It's actually easy to save money—when you buy United States Series E Savings Bonds through the automatic Payroll Savings Plan where you work! You just sign an application at your pay office; after that your saving is done for you. And the Bonds you receive will pay you interest at the rate of 3% per year, compounded semiannually, for as long as 19 years and 8 months if you wish! Sign up today! Or, if you're self-employed, invest in Bonds regularly where you bank. There's no surer place to put your money, for United States Savings Bonds are as safe as America!

Safe as America — U.S. Savings Bonds

The U.S. Government does not pay for this advertisement. It is donated by this publication in cooperation with the Advertising Council and the Magazine Publishers of America.

It's Portable!

Jacuzzi WHIRLPOOL BATH

Model J-300
PATENT
PENDING

Doubles usage... halves the cost

Versatile and economical . . . one unit serves all therapy tanks or bathtubs.

Adaptable. Can be placed in tank wherever needed for most beneficial effect. No clamps or bolting necessary.

Effective: Its ½ h.p. motor puts out forty-five gallons of churning, aerated water per minute! Force and direction of flow quickly, easily adjustable to patients' specific needs. No maintenance or extra plumbing required. Compact. Weighs only 25 lbs.

Proven: Developed and tested through seven years of research under supervision of physicians.

Safe: Accepted and fully approved for professional use by Underwriters Laboratories.

Jacuzzi WHIRLPOOL BATH

JACUZZI BROS. INC.
Hydrotherapy Division
1458 San Pablo Ave. - Berkeley 2 - California

Write for illustrated bulletin giving full details.

Made by the originators of the injector-type water system

Immobilize the entire lower back area

with CAMP

LUMBOSACRAL SUPPORTS

Camp Lumbosacral Supports cover and support the complete lumbar and sacral regions of the back. Their precise design in a wide range of styles and sizes permits authorized Camp dealers to stock the supports . . . eliminating delays caused by waiting for "special" manufacture. Their lower cost and comfort makes them especially attractive to your patients. Additional steels may be easily added for extra reinforcement. Camp's well-known "block and tackle" lacing adjustment feature increases the force that can be exerted by two to three times because of a three to one mechanical advantage.

S. H. CAMP and CO., Jackson, Mich.
World's Largest Manufacturer of Anatomical Supports
OFFICES: 200 Madison Ave., New York; Merchandise Mart, Chicago
FACTORIES: Windsor, Ontario; London, England

TO MAKE PRESCRIBING OF CAMP SUPPORTS EASIER WRITE FOR YOUR COPY OF THE PHYSICIANS AND SURGEONS REFERENCE BOOK FOR ADDITIONAL DETAILS ON THE COMPLETE CAMP LINE.

• EFFECTIVE THERAPY
Whether it's localization, long-path or broad area treatment . . .
THE VERSATILE, FLEXIBLE
L-F Model SW-660
FREQUENCY-CONTROLLED SHORT-WAVE
Diathermy
DOES IT ALL!
LF
LIEBEL-FLARSHEIM CO.
Cincinnati 15, Ohio
Gentlemen: Please send me descriptive literature on the L-F SW-660 diathermy . . . (without obligation).
NAME
ADDRESS
CITY
STATE

BIRTCHER
ULTRASONIC
THERAPY UNITS

Now Type Approved By The
Federal Communication Commission
F. C. C. Number U-102

For Detailed Information, write

BIRTCHER

4371 valley blvd., los angeles 32, calif.
APM&R:4/55